HERBERTIA

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HERBERTIA

the journal of the **International Bulb Society**, is devoted to the botany and horticulture of geophytic/bulbous plants. Special emphases of the journal are the Amaryllidaceae and other petalloid monocot families rich in bulbous or cormous plants, but articles treating any aspects of dicotyledonous geophytes are welcomed as well.

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*** NEW ADDRESS ***

INTERNATIONAL BULB SOCIETY
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UNITED STATES OF AMERICA

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In This Issue...

the genus *Hippeastrum* takes the spotlight as we present articles on its collection, breeding, cultivation, cytology and propagation.

Elisabeth Lassanyi, Assistant Editor

Cover: *Worsleya rayneri* ex hort. UCI Arboretum, California. Photo by H. Koopowitz.

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The Herbert Medal

The Herbert Medal is the highest honor the International Bulb Society can bestow upon persons distinguishing themselves by meritorious achievement in advancing the knowledge of bulbous plants, especially those of the Amaryllidaceae. The medal is named for William Herbert (1778-1847), son of Henry Herbert, Earl of Carnarvon. William Herbert had a prediliction for amaryllids and achieved success in their hybridization and published his research findings in several monumental works. His contributions as a pioneer geneticist and plant breeder, and his arrangement of the Amaryllidaceae, helped set the stage upon which other workers, both amateur and professional, have been able to advance. Below are listed those individuals honored as Herbert Medalists:

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Dr. H. Suichi Hirao, **Japan**, 1990
Dr. Kenneth E. Mann, **California**, 1991

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BULB SYMPOSIUM CANCELLED

The Directors of the International Bulb Society (IBS) have cancelled the Fourth International Symposium on Bulbous and Cormous Plants that was to be held from May 17-20, 1992, at Noordwijkerhout in the Netherlands.

Reasons for the cancellation include the worsening, world-wide economic recession and our inability to attract sufficient financial sponsorship to underwrite the symposium. The Directors feel that their primary responsibility is production of the journal **Herbertia** and the potentially enormous financial losses from the symposium would have jeopardized both the IBS and its ability to produce the journal.

Contributors are encouraged to participate in the International Society for Horticultural Science (ISHS) sixth International Symposium on Flowerbulbs in Skierniewice, Poland which is prepared to accept IBS speakers. Inquiries should be sent to the following address: ISHS Symposium, Pomologiczna 18, P.O. Box 105, 96-100 Skierniewice, Poland. That symposium is scheduled to run May 12-15, 1992. The organizers of that symposium are prepared to add additional sessions to accomodate IBS speakers who still wish to deliver their papers.

A great deal of time and effort over the last few years was expended on the IBS Symposium and it is a great disappointment to all concerned that plans can not be taken to fruition. Executive Director Fred Meyer spent a great deal of his own, personal time and money in organizing the speakers for the Symposium and the Board of Directors would like to express their gratitude for his efforts.

Hopefully, another IBS symposium will be organized in the future when conditions are more favorable. Until then we will focus our efforts on producing a timely journal and also providing you with one of the world's best seed lists for petaloid, monocotyledonous plants.

IN MEMORIAM

A contribution of $25 to the International Bulb Society general fund has been made in the memory of IRMA WERLING. Donated by KENNETH MANN.

(Contributions for the "in memoriam" page may be in any amount and should be made by check or money order. If you wish to specify a certain project for your contribution such as the scholarship fund, improving **Herbertia**, or revision of **Amaryllidaceae**, please so indicate. Those "in memoriam" contributions which do not specify a project will be placed in the general fund of the International Bulb Society.)

BEQUEST APPEAL

The Board of Directors of the INTERNATIONAL BULB SOCIETY is making a special appeal to those of you who would like to promote the cause of ornamental, bulbous plants. The board asks that your last will and testament include a bequest to the INTERNATIONAL BULB SOCIETY. There's so much more your Society could do if only the funds were available:

- more extensive field collecting trips to help save the world's disappearing plant species;
- scholarships for deserving young botanists and horticulturists;
- more color in future editions of HERBERTIA;
- publication of a revised edition of "AMARYLLIDACEAE" and other monographs.

These are just a few of the plans being made for the society's future. The Board is asking that you become a part of these plans. Please write a bequest into your will to:

INTERNATIONAL BULB SOCIETY
c/o Dr. Harold Koopowitz, Arboretum
University of California, Irvine
Irvine, CA 92717
United States of America

Swap Column

Exchanging plants and seeds is one of the most satisfying of all the benefits which come to gardeners. Many a friendship has blossomed along with the plants and seeds exchanged. To promote such plant and seed exchanges, a page in each future edition of HERBERTIA will be devoted to a Swap Column. If you are having trouble locating certain bulbs or plants, send in your request addressed to: Swap Column, The International Bulb Society, c/o UCI Arboretum, University of California at Irvine, Irvine CA 92717, United States of America. Requests should be limited to one or two sentences in length and writen in this form:

Jane Smith, street address, city, state/region, postal code, (country name) is interested in locating bulbs or seeds of *Species name* 'Cultivar Name'. Please contact her at the above address. (This is an example, *not* a real request.)

Fritz E. Dederer, 114 Maria Moczo Street, Santurce, PR 00911-2214 United States of America, is looking for sources of *Worsleya rayneri*, the "blue amaryllis". He is also interested in contacting suppliers of *Crinum* and other amaryllids which may thrive in Puerto Rico's year round warm climate. Please contact him if you have information on suppliers of these plants. (This *is* a real request.)

James Sleznick, Jr., Pinnacles National Monument, Paicines CA 95043, United States of America, wishes to locate a source of *Hymenocallis narcissiflora* (also known as "spider flower" or "basket flower"). Please write to him if you know of a reliable source. (This is also a real request.)

Before submitting a swap column request, check the International Bulb Society Seed Exchange List, available to members upon request, to see if the plants for which you are interested are available through the Exchange. The Seed Exchange address is listed on page iii.

HIPPEASTRUM BREEDING AT THE UNIVERSITY OF FLORIDA

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Hippeastrum Herbert, the amaryllis, has yielded large-flowered, tetraploid hybrids over a 200 year breeding history (Meerow 1988, Traub 1934b, 1958). Bulbs are produced for indoor forcing and, to a lesser extent, garden use in mild winter areas (USDA Zones 8 to 11). The initial center of amaryllis breeding was Holland, with the Ludwig strains rapidly becoming the dominant genotypes among Dutch amaryllis (Ludwig & Co. 1948, Meerow 1988). South Africa has also now become an important breeding center and exporter of amaryllis (Barnhoorn 1976, Buck 1961, Goedert 1961). Florida was at one time a substantial producer of hybrid amaryllis bulbs and also hosted the breeding efforts of Henry Nehrling (Traub 1934a) and Theodore Mead (Bell 1973a, Hayward 1934). The Mead hybrids in particular, originating from Nehrling's germplasm, have contributed to modern hybrids when crossed with Ludwig or other Dutch stock (Bell 1973a). Though the Mead hybrids did not match the Dutch material in flower size and number of scapes produced, they were reliable and vigorous performers under Florida garden conditions (Bell 1973a, Goedert 1982). As amaryllis production in Florida faded, the result of disease, competition, and failures in quality control, much of this germplasm has been lost.

Hippeastrum consists of ca. 60 entirely New World species (Traub & Moldenke 1949). The species are concentrated in two main areas of diversity, one in eastern Brazil and the other in the central southern Andes of Peru, Bolivia and Argentina, on the eastern slopes and adjacent foothills. Little of this genetic diversity is represented in modern amaryllis hybrids. Primary hybrids were produced from a relatively small number of species, mainly *H. vittatum* Herbert, *H. leopoldii* Dombrain, *H. pardinum* (Hook. f.) Lemaire, *H. reginae* Herbert, *H. puniceum* (Lamarck) Voss and *H. aulicum* Herbert (Bell 1973a, Cage 1978a, Meerow 1988, Shields 1979, Traub 1934a). *Hippeastrum* x 'Johnsonii,' generally acknowledged as the first amaryllis hybrid, was a primary hybrid of *H. vittatum* and *H. reginae* (Traub 1934a). The emphasis in





Left to right, from top:
Figure 1. **H-1:** *H. papilio* x *H. lapacense*
Figure 2. **H-2:** *H. lapacense* x *H. papilio*

Figure 3. **H-4:** *H. vittatum* var. *tweedianum* x *H. papilio*
Figure 4. **H-5:** *H. papilio* x *H. vittatum* var. *tweedianum*
Figure 5. **H-8:** *H. cardenasianum* x *H. papilio*

Right:
Figure 6. Seedling of *H. papilio* x *H. reticulatium* var. *striatifolium*.

commercial breeding efforts has always been on large flower size, a trait attributable specifically to genes originating in *H. leopoldii* and *H. pardinum* (Bell 1973a, Shields 1979). Commercial breeding efforts subsequent to the initial flurry of primary hybridization have largely been concentrated among the hybrids themselves, leading to a greater complexity of parentage (much without documentation) and dilution of many of the unique characteristics of the original component species (Bell 1973a, 1973b; Cage 1978a, Meerow 1988, Shields 1979).

The overwhelming majority of *Hippeastrum* species are diploid, with a somatic chromosome number of $2n = 22$ (Arroyo 1982, Dutilh 1987, Flory & Coulthard 1981, Naranjo & Andrada 1975). Virtually all of the complex hybrid material presently in cultivation is tetraploid (Bell 1973a, 1973b, 1977a, Shields 1979), a result of both selection for tetraploid progeny (often associated with plant and flower size increases in hybrid amaryllis) and incorporation of a few natural tetraploid species in early hybridization efforts. The concentration of recent commercial breeding efforts among the various populations of tetraploids may exist for several reasons: 1) desirable characteristics of flower size, scape number, and plant vigor are already stabilized in the hybrid races; 2) sterile triploid progeny result when diploid species are crossed with tetraploid hybrids (Bell 1973b, 1977a); 3) many of the diploid species are not readily available; and 4) self-incompatibility, which occurs in most diploid species and diploid hybrids, generally breaks down in the tetraploid hybrids (Bell 1973b, 1977a; Cage 1978, Shields 1979, Williams 1980), thereby allowing breeders to obtain a segregating F-2 generation.

The result of these constraints, whether voluntary or involuntary, on commercial amaryllis breeding has been a similarity to many of the modern hybrids. The flowers, while large, tend to be of the wide, flat, "dinner-plate" type with little variety of form and limited variation in color (Doran 1982), despite repeated call for renewed programs of interspecific hybridization (Bell 1973a, 1977a; Buck 1978, Cage 1978a, Doran 1982, Shields 1979).

The pursuit of novelty in amaryllis hybrids has largely been the province of amateur breeders and collectors, most of whom have little inclination to commercially exploit their hobby or have not succeeded in their attempts to do so (Cage 1978b, Cothran 1979, Doran 1982, Wilson 1981). Breeding efforts by amateurs have largely been ignored by European breeders with the possible exception of attempts to develop a large-flowered yellow hybrid (Blossfeld 1973, Cothran 1979, 1981, 1984, 1985; Goedert 1982). There has also been some commercial interest in double-flowered varieties (Bell 1977b).

Amaryllis hybrids could be improved in a number of ways (Bell 1973a, 1977a; Cage 1978a, Shields 1979). These include novel attributes of flower form (e.g.: trumpet or long-tubed perianth, novel pigmentation patterns), re-introduction of fragrance, evergreen foliage, repeat bloom, as well as along more strictly cultural criteria [resistance to *Hippeastrum* mosiac virus, red scorch (*Stagonsopora curtisii*), and bacterial and fungal bulb rots].

Using a number of interesting diploid species, we have begun a breeding program directed towards some of the aforementioned goals. Most of these

species are also deserving of cultivation on their own merits, particularly in light of their rarity and destruction of their tropical habitats (Bell 1973a, Shields 1979). Concurrent with our breeding program, we are establishing a collection of *Hippeastrum* germplasm in association with Brazilian and domestic colleagues such as Julie Dutilh and Fred Meyer. Attempts to increase the supply of rare species via tissue culture are underway as well. Ultimately, we endeavor to develop a breeding gene pool largely unrelated to the genetic stock now represented in the commercial amaryllis production industry, largely dominated by the Dutch. Fortunately, the American Floral Endowment has found this work deserving of at least one year's funding, and we are hopeful of receiving renewed support in the upcoming year.

We have successfully produced reciprocal F_1 progeny between *H. papilio* and, respectively, *H. lapacense*, *H. cardenasianum*, and *H. vittatum* var. *tweedianum*. Reciprocal crosses between *H. lapacense* and *H. cardenasianum* have also been accomplished, but further work with these two crosses is not planned. Five crosses are currently under evaluation during their first flowering, less than 2 years from seed. Flowering began in February, 1990 and is still continuing at this writing. Over two hundred seedlings have been evaluated. Results of the F_1 are summarized below and in Table 1. A few representative clones are illustrated in Figs. 1-5. Overall selection criteria include flower size, flower number (> 3 being desirable), repeat bloom, and leaf persistence.

Table 1. Summary of the 1990 Amaryllis F_1 Evaluation (As of 7/1/90).

Cross	Total Evaluated	Scapes Produced					Number With 3 or More Flowers Per Scape	Grade		
		1	2	3	4	5		Good	Fair	Poor
H-1	54	31	21	2			15	12	40	2
H-2	53	19	30	4			9	14	32	7
H-4	39	16	13	9	1		4	15	21	3
H-5	27	13	10	1	2	1	7	4	20	3
H-8	33	16	12	1	4		8	7	25	1

H-1: *H. papilio* x *H. lapacense* (Fig. 1). "Butterfly" form, red to maroon freckling and striations overlying a white to green background. A few clones with the upper and lateral petals deeply suffused with red. Foliage quality good, dark green, persistent. Selection criteria: pure red rather than maroon, pure white background, wide petals. Most show the red picotee of the papilio parent.

H-2: *H. lapacense* x *H. papilio* (Fig. 2). Similar to H-1 in form, color, and foliage, but a fair number more lightly striated over the white or green background. Selection criteria as for H-1.

H-4: *H. vittatum* var. *tweedianum* x *H. papilio* (Fig. 3). Quite variable,

about half with trumpet-shaped flower, the other half more open-faced. Most with red picotee. Several with a unique purple pigmentation over a white background. Foliage quality good, lighter green than H-1 or H-2. Some very robust and vigorous growers. Selection criteria: trumpet shape, purple color, white background.

H-5: *H. papilio* x *H. vittatum* var. *tweedianum* (Fig 4). Similar to H-4. Most tend to show picotee from *H. papilio* parent. Long-lasting flower of heavy substance. Selection criteria: spreading petals, white background.

H-8: *H. cardenasianum* x *H. papilio* (Fig. 5). Very elegant flower form, semi-star. Pink to maroon striations over a white to light green background. Excellent foliage quality, including some very compact clones. Flowers of medium substance. Selection criteria: less green in background, clear red or pink pigmentation.

Sibling and inter-hybrid crosses have been made using outstanding selections from the F_1 progeny. Second generation crosses between H-8 selections and outstanding progeny of H-1 and H-2 respectively are expected to yield promising results. New primary hybrid populations have been generated with *H. papilio*, *H.* 'Encore' and 'Pink Ambrosia' (the latter two heavily fragrant, trumpet-flowered hybrids of Len Doran's); a number of hybrid selections from the breeding program of Fred Meyer, Escondido, CA involving *H. tucamanii*, *H. brasilensis*, *H. fragantissimum* (all fragrant, trumpet-flowered species); and *H. reticulatum* var. *striatifolium* (a dwarf species with a novel and cross transmittable white leaf midrib) as the seed and pollen parents. As of this writing, 38 second generation crosses have been successfully accomplished and over 2000 seedlings are in production. We estimate flowering these seedlings in fall and/or spring of 1992. A number of the *H. papilio* x *H. reticulatum* var. *striatifolium* hybrids are exhibiting the white midrib of the pollen parent (Fig. 6). The new leaves of these hybrids emerge an attractive bronze to almost red color.

The bulbs are grown in trial beds that receive full sun from noon to sunset at the Fort Lauderdale Research & Education Center in Fort Lauderdale. Ten percent of each hybrid population is also maintained in containers under 63% shade.

In crosses now setting, approximately 20% of the germinated seedlings have been or will be treated with colchicine using the methods of Williams (1982) in an attempt to induce tetraploidy in some of the progeny. Germinated seedlings are inverted to the midpoint of the seedling bulbil in 0.05% colchicine in agar for 24 hours. Root tip squashes will be used for determination of ploidy level (Meerow 1987).

Superior selections from the breeding program will be increased through tissue culture using the twin-scaling method (Alderson and Rice 1986, Bose and Jana 1977, Phunsiri et al. 1982, Seabrook and Cumming 1977) and tested for both pot crop and landscape potential. Irradiation of aseptic subcultures of the superior F_1's will also be attempted (Kaicker and Singh 1979).

It is imperative that a programming schedule for flower induction and development be formulated before any cultivar is released from the program. There is literature on plant growth regulator (Bhattacharjee 1983; Maiko and Aksonova 1982, 1983), environmental (Blaauw 1931; Boyle and Stimart 1987; Kozlova 1981; Bose et al. 1981; Hayashi 1972, 1974; Hayashi and Suzuki 1970; Hong 1970) and nutritional (Bose et al. 1980, Jana and Bose 1980) effects on flower forcing in *Hippeastrum*, expressly relating to the complex hybrid material that currently dominates the trade. Experiments will be conducted to determine the protocols necessary to force selections from the breeding program. Additional studies underway include an investigation into the

relationship between ammoniacal nitrogen as a nutrient source and susceptibility to bulb rot diseases.

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HIPPEASTRUM PARDINUM CROSSED TO A WHITE *H. HYBRIDUM* I. SEGREGATION OF THE B CHROMOSOME

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THE CROSS AND THE CHROMOSOMES

Twenty-five years ago one of us (G.I.) had a bulb of *Hippeastrum pardinum* which gave a few seeds as a pistil parent in a cross to a large white flowering *H. hybridum*. Only four seeds germinated and grew up. The first pictures (Fig. 1a-d) show the mother plant, *H. pardinum*, and three of these hybrids. As these three are not identical, there must have been heterozygosity in at least one of the parents, most likely the white *H. hybridum*.

The chromosomes were studied in root tips from *H. pardinum* and the four hybrid plants. All five had, in addition to the ordinary twenty two chromosomes (A-chromosomes), one B-chromosome. This is easily distinguished from the rest of the karyotype by its characteristic morphology. It is relatively small, like most of the B-chromosomes, and it has a subterminal centromeric constriction. The chromosomes of *H. pardinum* are shown in figure 2a. The diagram (Figure 2b) illustrates the variation in chromosome size for ten cells. On the X scale is the index short arm/long arm and on the Y scale the chromosome length expressed in percentage of the length of the diploid chromosome set (except the B.) The characteristics of the chromosomes of *H. pardinum* are summarized in Table 1.

Table 1. Relative chromosome length and arm index (short arm/long arm) for the chromosomes of *Hippeastrum pardinum* (the relative length is expressed in % of the length of the diploid chromosome set.)

Chromosome:	1	2	3	4	5	6
Rel. length in %	6.49	6.44	5.71	5.54	4.86	4.92
Arm index	0.362	0.454	0.391	0.296	0.350	0.174
Chromosome:	**7**	**8**	**9**	**10**	**11**	**B**
Rel. length in %	4.33	3.13	2.98	2.79	2.81	2.88
Arm index	0.177	0.617	0.740	0.863	0.955	0.262

Some cells of the four triploid hybrid plants were also analyzed and are presented in similar diagrams (Fig. 3a-d). Each point, representing a

chromosome, has with a line been connected to the mean of the most likely chromosome type taken from the ideogram of *H. pardinum*. It may be pointed out here that there are some probably regular deviations from the expected means. For the plant called 'Am1' with an exact triploid chromosome number ($2n$=33+B) there are no such deviations. However, for the other three plants, which all have one or two chromosomes less than the triploid number, there are small, regular deviations in measured chromosome morphology, especially as to arm index. Thus, for the plant called 'Am2' the chromosomes 5, 6, 7, and 8 have all a smaller arm index than corresponding chromosomes of *H. pardinum*. In contrast to this the small chromosomes 10 and 11 seem to have a larger index (near to value 1) than is found in *H. pardinum*. For 'Am3' and

Figure 1. *Hippeastrum pardinum* (a) and three triploid offspring, *H. pardinum* x *H. hybridum*, showing heterozygosity. "Am1", $2n$=33+B (b); "Am2", $2n$=31+B (c); "Am4", $2n$=32+B (d).

'Am4' there is a similar effect even if it is not that evident. Thus, in 'Am3' mainly chromosome 5 seems to be affected and in 'Am4' mainly chromosome 7. As similar effects on arm index also have been observed in different trisomics of *Tradescantia paludosa* (G. Ising, unpublished), it is certainly not a spurious observation, but it may rather have something to do with the relative spiralization rate in the long and short chromosome arms.

Two chromosomes are missing compared to the triploid set in 'Am2'. These are, most likely, one chromosome 1 and one chromosome 9. For 'Am3' most likely one chromosome 1 is missing and for 'Am4' most likely one chromosome 4. Such interchromosomal effects on chromosome morphology makes it difficult to determine which chromosomes are missing in aneuploids from a tetraploid-triploid cross. It has, therefore, been necessary to limit such a characterization to the number of chromosomes in each of the following three groups:

1. Long chromosomes with submedian centromeres - Lsm.
2. Long chromosomes with subterminal centromeres - Lst.
3. Short chromosomes with almost median centromeres - Sm.

In addition to these three groups there is the short B chromosome with a subterminal centromere.

CHROMOSOME SEGREGATION IN THE BACK-CROSSES

When the triploid plants named 'Am1' and 'Am4' first flowered (in 1966) they were used both as pistil and pollen parents to some *H. hybridum* plants, which happened to flower simultaneously. Similar crosses were performed during the following three years and table 2 gives a summary of the result. The crosses numbered from I to XVIII have been followed and studied for many years. The results as to the segregation for different chromosome types and flower characteristics will be dealt with more in detail in a following paper. Here we will mainly consider the effects of the B chromosome.

It is clear from table 2 that the triploid plant called 'AM1' is not useful as a pistil parent in spite of having exactly the triploid chromosome number. Surprisingly, the aneuploid triploid 'Am4' which is missing one of the long chromosomes with a submedian centromere (compared to the exact triploid number) is to some extent useful as a pistil parent. Three pods from six pollinated flowers produced together 75 seeds of which almost 50% germinated. In the reciprocal cross this triploid plant was a little less successful - only four pods developed from fourteen pollinated flowers and of the 88 seeds only 30 germinated. Contrary to this, the exact triploid 'Am1' which was completely sterile as pistil parent resulted in a better seed set when used as a pollen parent. Thirteen of twenty-five pollinated flowers resulted in 542 seeds of which 414 germinated. The chromosomes have been studied for many plants in these crosses and the result is summarized in tables 3 and 4.

Table 2. Crosses between triploids and tetraploids of *Hippeastrum*

Year	Triploid x Tetraploid	Poll. flowers	Capsules	Seeds	Plants	Cross #
1966	'Am1' x 'White cl. 16'	3	0	0		
1967,8	'Am1' x Different Red	21	0	0		
1966	'Am4' x 'White cl. 16'	1	1	15	5	Am4: 1-5
1967	'Am4' x 'Red I & M'	3	1	32	20	VI
1967	'Am4' x *H. gracilis*	2	1	28	8	XI
1966	'White cl. 16' x 'Am1'	3	3	159	127	I, II, III
1967	'New White' x 'Am1'	4	2	80	62	VIII, IX
1967	'Personality' x 'Am1'	1	1	16	6	VII
1968	'Red 5:1' x 'Am1'	2	1	40	24	XII
1968	'Red 5:3' x 'Am1'	3	2	81	61	XIII, XIV
1969	'White cl. 20' x 'Am1'	6	3	120	106	XV, XVI, XVII
1969	'Semi-miniata' x 'Am1'	2	1	46	28	XVIII
1966	'White cl. 16' x 'Am4'	5	1	33	19	IV
1967	'Red I' x 'Am4'	3	2	2	1	V
1967	'Personality' x 'Am4'	2	1	53	10	X
1967	'New White' x 'Am4'	4	0	0		

Figure 2a. A photograph of the 22 A-chromosomes and the B-chromosome (indicated by an arrow) of *Hippeastrum pardinum*.

Figure 2b. A graph of ten cells of *H. pardinum* showing the variation in chromosome morphology. The X-axis = arm index (i.e.: short arm divided by long arm) & the Y-axis = length in % of two chromosome sets.

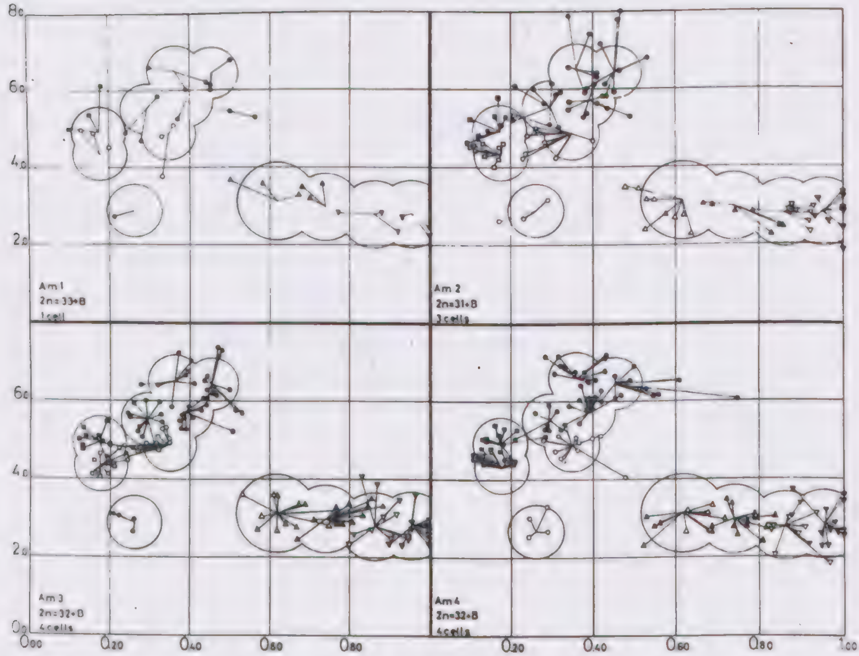

Figure 3. Four graphs showing variation in chromosome morphology of the four triploid hybrids: "Am1" (1 cell), "Am2" (3 cells), "Am3" (4 cells), and "Am4" (4 cells). Two A-chromosomes from each cell are connected with the nearest of the eleven chromosome means in figure 2b. Similarly the B-chromosome in each cell is connected with the mean for the B from the ten cells of *H. pardiinum* (x=0.262; y=2.88).

Table 3. Hypotriploid (2*n*=32+B) x Tetraploid (4x)

Chr.# in progeny	37+B	38	38+B	39+B	40+B	41+B	42+B	43+B	54+B	Total	Mean
'Am4' x White clone 16	0	0	0	0	1	1	1	1	1	5	
'Am4' x *H. gracilis*	2	1	1	2	5	0	4	2	0	17	
Total	2	1	1	2	6	1	5	3	1	22	40.3

Table 4. Tetraploid ($2n$=44) x Triploid ($2n$=33+B)															
Chr. # in progeny	33	34	35	36	37	38	39	40	41	42	43	44	45	Total	Mean
With B Chrom.:	0	0	0	1	1	0	5	9	15	19	29	28	2	109	42.294
Without B:	4	1	1	2	0	0	2	12	0	7	11	9	0	49	40.694
Total	4	1	1	3	1	0	7	21	15	26	40	37	2	158	41.797

Of the twenty-two plants in Table 3, all except one have got the B chromosome from the maternal plant. Taking into account also the four triploid plants 'Am1'-'Am4', which as well had a mother plant with a B chromosome, there are 25 cases out of 26 where the B has gone to the egg cell in a plant having one B. This deviation from an expected 1:1 segregation is highly significant ($p< 0.1\%$). Consequently we can take it for granted that there is a preferential segregation of the B chromosome on the female side in *Hippeastrum*. Most likely it is the same phenomenon as in *Lilium callosum* (Kayano, H. 1957) where the B goes preferentially to the egg cell in the first meiotic division. The plant with $2n$=54+B in Table 3 is apparently the result of an unreduced female gamete with 32+B and a pollen grain with 22 chromosomes.

THE EFFECT OF THE B CHROMOSOME ON OTHER CHROMOSOMES

The chromosome numbers in Tables 3 and 4 varies between 33 and 45 if the pentaploid with $2n$=54+B is not counted. From Table 4 it is clear that there is a deviating segregation for the B chromosome also on the male side. The ratio of 109 plants with a B chromosome against 49 without a B is significantly deviating ($p<0.1\%$) from the expected one (79:79). This deviation may either depend on a faster growing rate for pollen tubes with B or on a more efficient fertilization of the egg cells by sperm kernels having a B. If pollen tubes with a B chromosome grow faster than pollen tubes without, this may to some extent compensate for a reduced growing rate of pollen grains with many extra chromosomes in addition to the haploid number. Such a reduction in growing rate for pollen grains having extra chromosomes has been found in *Cyrtanthus* (Ising, 1969). In *Hippeastrum* there are clear differences in all the three morphological chromosome types as to mean chromosome number in plants with a B compared to plants without a B (Table 5).

Table 5. Effect of the B chromosome on the frequency of other chromosome types in the cross 4x x 3x+B. (Only 148 of the 158 plants have been characterized as to morphological types of chromosomes.) The table gives the mean chromosome number for the number of individuals given in parenthesis.

Chromosome type	Plants with B (n)	Plants without B (n)	Diff.	t-value	Probability
Lsm	19.707 (99)	18.898 (49)	0.809	4.138	0.001
Lst	7.596 (99)	7.286 (49)	0.310	2.006	0.057
Sm	15.111 (99)	14.592 (49)	0.519	2.637	0.009
All chromosomes	42.294 (109)	40.694 (49)	1.600	3.996	0.0001

About half of the difference between chromosome numbers in plants which have got a B chromosome and plants which have not may be ascribed to the five long submedian chromosomes. This gives a mean effect of 0.162 for each chromosome. For the two chromosomes of Lst type there is a mean effect of 0.155, i.e. an almost identical value as for the Lsm type. For the four smallest chromosomes, which make up the Sm group, the mean value is 0.130. Thus, all the eleven chromosomes may be affected by the B to about the same degree.

The most striking fact from table 4 is that no plants with $2n$=33-35 and only one with 36 and one with 37 chromosomes are found among the 109 individuals with a B chromosome. Eight such plants are found among the 49 plants without a B. With the same frequency among the 109 B chromosome plants, we had expected 18 plants instead of two with $2n$=33-37. Let us suppose that there had been sixteen more plants with a mean of 35 chromosomes and sixteen less with a mean of 42.5, then there would be (16 x 7.5)=120 fewer chromosomes among plants with a B, which had reduced the mean chromosome number with 1.1. Thus, most of the difference found between plants with a B and without a B may depend on the fact that pollen grains with fifteen or fewer chromosomes have difficulties to compete with the other pollen grains if they also have a B chromosome. The reason for this effect is difficult to explain and demands further studies.

One thing is clear after the result described above – when considering an eventual effect of the B chromosome on different characters, the effect of B on the frequency of the other chromosomes must also be taken into account.

THE B CHROMOSOME AND SOME FLOWER CHARACTERS

Most of the plants reported in table 4 have flowered one or several times. Two different crosses between the red triploid "Am1" and two white

flowering *H. hybridum* will be dealt with here. These two white plants are called "White clone 16" and "New white". In the first cross there are 80 plants that have flowered, and in the second, 22. As the two crosses give different means for some characters as well as for some chromosome types, they have been treated separately when correlations between chromosomes and characters are studied. In Table 6 are shown characters studied in the two crosses between white tetraploids and the triploid "Am1". The mean number for each character is given in the table.

Table 6. Characters studied in two crosses between white tetraploids and the triploid "Am1". (All measurements are in mm. –*=probability between 1 and 5%, **=probability between 0.1 and 1%, and ***=probability less than 0.1%

Cross	2*n*	Lsm	Lst	Sm	B	Flowering times	No. of flws.	Petal length
First	41.963	19.575	7.475	14.913	0.763	4.262	2.762	109.321
Second	40.818	18.864	7.455	14.500	0.545	6.091	2.633	108.965
Diff.	1.145	0.711*	0.020	0.413	0.218	-1.829**	0.129	0.356
t-value	1.97	2.48	0.12	1.52	1.93	2.96	0.92	0.12

Cross	Upper-most petal width	Lowest petal width	Tube length	Pedicel length	% red colour	Spotted or not spotted	Spot frequency
First	75.142	46.709	19.969	45.987	51.664	0.525	1.762
Second	71.537	43.746	18.153	52.009	55.479	0.318	1.329
Diff.	3.605	2.963	1.816*	-6.122*	-3.815	0.207	0.433
t-value	1.51	1.85	2.60	2.02	0.35	1.73	0.98

From Table 6 it is clear that the two crosses are not similar in respect to all characters. The plants in the first cross (I, II, III in Table 2) have in mean got one chromosome more than the plants in the second cross (VIII and IX in Table 2.) Two of the three chromosome types are involved in this difference, type Lsm occurring with 0.7 more in the first cross and type Sm with 0.4 more than they do in the second cross. Even the B chromosome occurs more frequently in the first (60 of 80 plants) than in the second cross (12 of 22 plants.) The last difference is, however, not significant. The plants of the second cross have flowered more frequently during the years (6.1 times) than the plants in the first cross (4.3 times). This difference is highly significant,

which means that the chance that the difference is found is accidental is less than 1% (**). There are two more differences which, most likely, are not accidental. Tube length is 1.8mm longer in the first cross than in the second. Pedicel length is 6.1mm longer in the second than in the first cross. Also, the petals seem to be a few mm broader in the first compared to the second cross but this difference is not significant.

In the two different crosses as well as in the total material, the correlation coefficients (r) for the presence versus absence of B and the different chromosome types and flower characters were studied. These coefficients are summarized in table 7, where the probability (p) that a correlation coefficient differs from zero is also given.

From Table 7 it is clear that it is difficult to prove any real effect of the B chromosome more than the correlation to the different chromosome types, which was shown already in table 5. However, the correlation between B and chromosomes of types Lsm and Sm are much more evident in the second cross than in the first. On the contrary, the correlation between B and chromosomes of type Lst seems to be more pronounced in the first cross. To some extent this may depend on the fact that only 22 plants have flowered and been studied cytologically of the 62 seedlings in the second cross compared to 80 out of 127 seedlings in the first cross. As to the flower characters, there are indications that plants with a B chromosome will flower more frequently than plants without a B (Figure 4). Also, the spot frequency in spotted plants seems to be much higher in plants with a B chromosome than in plants without a B, at least in the first cross.

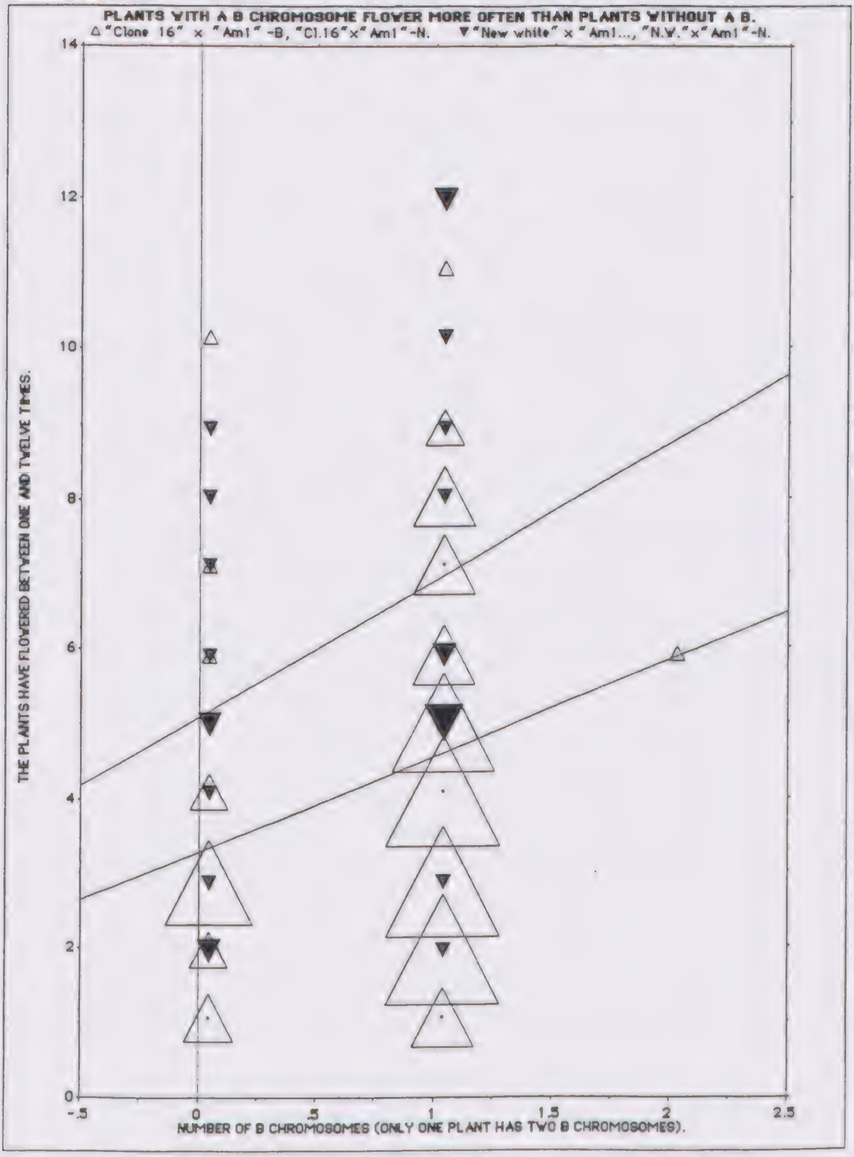

Figure 4. Graph of occurrences of flowering versus number of B-chromosomes. Plants with a B chromosome will flower more often than plants without a B. This holds for both the crosses even if it is not significant for the second cross (cf. Table 7.)

Table 7. Correlation between presence or absence of B and the frequency of other chromosomes as well as between B and the value for a number of flower characters. The correlation coefficients and the p-values are given. First cross n=80, second cross n=22, except for "spot frequency in spotted" where n=46 and 7, respectively. (A minus before the correlation coefficient means that there is a negative regression, i.e.: plants with a B chromosome have a lower value for the actual character than plants without a B.)

Cross	2*n*	Chromosome type			Flowering times	No. of flowers	Petal length	Uppermost petal width	Lowest petal width
		Lsm	Lst	Sm					
First r	0.314**	0.170	0.323**	0.222*	0.229*	-0.026	-0.004	0.036	-0.135
p	0.005	0.131	0.004	0.048	0.041	0.818	0.975	0.753	0.233
2nd r	0.620**	0.635**	0.180	0.719***	0.308	-0.563**	0.539**	0.301	0.424*
p	0.002	0.002	0.423	0.0002	0.163	0.006	0.010	0.173	0.049
Total r	0.436***	0.365***	0.282**	0.374***	0.188	-0.143	0.104	0.119	0.030
p	0.0001	0.0002	0.004	0.0001	0.058	0.152	0.300	0.234	0.763

Table 7 (continued)

Cross		Tube Length	Pedicel Length	Dominant colour red=1, white=0	% red colour	Spotted or not spotted	Spot frequency
First	r	-0.039	-0.100	0.270*	0.236*	0.029(n=80)	0.410** (n=42)
	p	0.729	0.376	0.016	0.037	0.799	0.007
Second	r	0.154	-0.174	0.100	-0.060	-0.036 (n=22)	0.162 (n=7)
	p	0.495	0.438	0.658	0.791	0.875	0.729
Total	r	0.084	-0.069	0.175	0.153	0.003	0.389**
	p	0.400	0.492	0.079	0.126	0.860	0.006

Within the two different crosses there are relations between B and some flower characters. In the first cross there is a correlation between the presence versus absence of a B chromosome and red versus white colour. For the total material this is not significant. In the second cross there are correlations between the presence of the B chromosome and a lower number of flowers as well as longer and broader petals. These effects may be an indirect

effect of the very strong correlation between the B chromosome and the chromosomes of types Lsm ($r=0.635^{**}$) and Sm ($r=0.719^{***}$) in this cross. Therefore, the correlation between these three characters and the number of each of the three different chromosome types has also been studied in the two crosses (Tables 8 and 9). In the two tables are also included percent of red colour and spot frequency in spotted plants.

Table 8. Correlation coefficients for number of different chromosome types and some flower characters in the first cross ('White clone 16' x 'Am1'), *n*=80.

Chromosome type	Lsm		Lst		Sm		All Chromosomes	
	r	p	r	p	r	p	r	p
# of flowers	-0.058	-0.607	-0.059	0.605	-0.065	0.569	-0.084	0.461
Petal length	0.157	0.164	0.095	0.404	0.050	0.659	0.135	0.232
Petal width[1]	0.337^{**}	0.002	0.019	0.867	0.095	0.400	0.115	0.309
% red colour	-0.080	0.484	0.088	0.439	0.178	0.117	0.089	0.434
Spot freq., (*n*=42)	-0.150	0.344	0.139	0.380	0.176	0.266	0.125	0.431

[1]Lowest petal.

Table 9. Correlation coefficients for number of different chromosome types and some flower characters in the second cross ('New White' x 'Am1'), *n*=22.

Chromosome type	Lsm		Lst		Sm		All Chromosomes	
	r	p	r	p	r	p	r	p
# of flowers	-0.098	0.665	0.320	0.147	-0.200	0.372	-0.051	0.822
Petal length	0.601^{**}	0.003	0.466^{*}	0.029	0.640^{***}	0.001	0.637^{**}	0.0014
Petal width	0.459^{*}	0.032	0.437^{*}	0.042	0.515^{*}	0.014	0.513^{*}	0.015
% red colour	-0.075	0.740	0.098	0.666	0.055	0.807	0.003	0.990
Spot Freq. (*n*=7)	0.591	0.162	0.480	0.275	0.886^{**}	0.008	0.798^{*}	0.031

In the first cross (Table 8) almost all correlation coefficients are insignificant. Only one is significantly positive, namely the effect of the chromosomes of type Lsm on the width of the lowest petal. As this positive correlation is very significant for both types of crosses, it seems likely that it reflects a real genetic effect on petal width of one or several genes in the chromosomes of type Lsm (Figure 5).

In the second cross (Table 9), which comprises only 22 individuals, it is very likely that all the chromosome types may have genes which have a positive effect on petal length and petal width. Consequently the conceivable effect of chromosome B on these characters may be indirect. It may reflect a real or incidental positive correlation between the B and the chromosomes of types Lsm and Sm in this cross.

In conclusion to this analysis we can say that the only likely effect of the B chromosome, except its effect on the other chromosomes, may be its effect on spot frequency in spotted plants. To illustrate this effect three spotted plants with one B chromosome each are compared to three spotted without B in Figures 6a-f.

DISCUSSION

1. Presence and Frequency of B Chromosomes

Some plants have B chromosomes in addition to the normal chromosomes. These occur in a variable number and are not necessary for the survival of the individuals. With few exceptions they are smaller than the normal A chromosomes and have very often a distinct morphology. They are usually heterochromatic and may contain very few functional genes. Among plants there are families where 10% or more of the species contain B chromosomes (Jones and Rees, 1982). Thus, in Amaryllidaceae and Liliaceae about 8% of the species studied have B chromosomes (Table 10.)

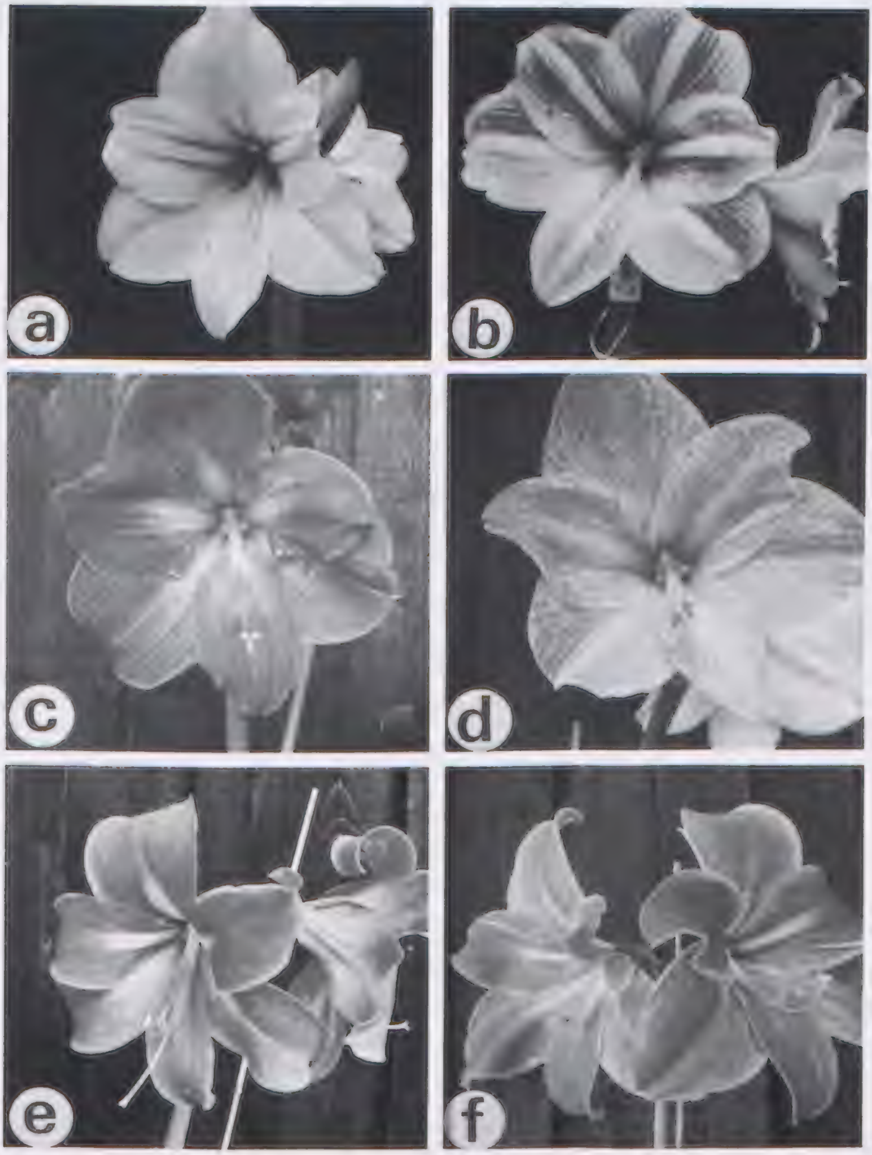

Figure 6. Six spotted flowers, three with and three without a B chromosome. Plants with a B chromosome usually have more spots than plants without a B. Plant numbers: a. I:22, $2n$+44; b. I:32, $2n$=43B; c. III:10, $2n$=43; d. I:9, $2n$=41+B; e. II:2 $2n$=43; f. I:26, $2n$=44+B.

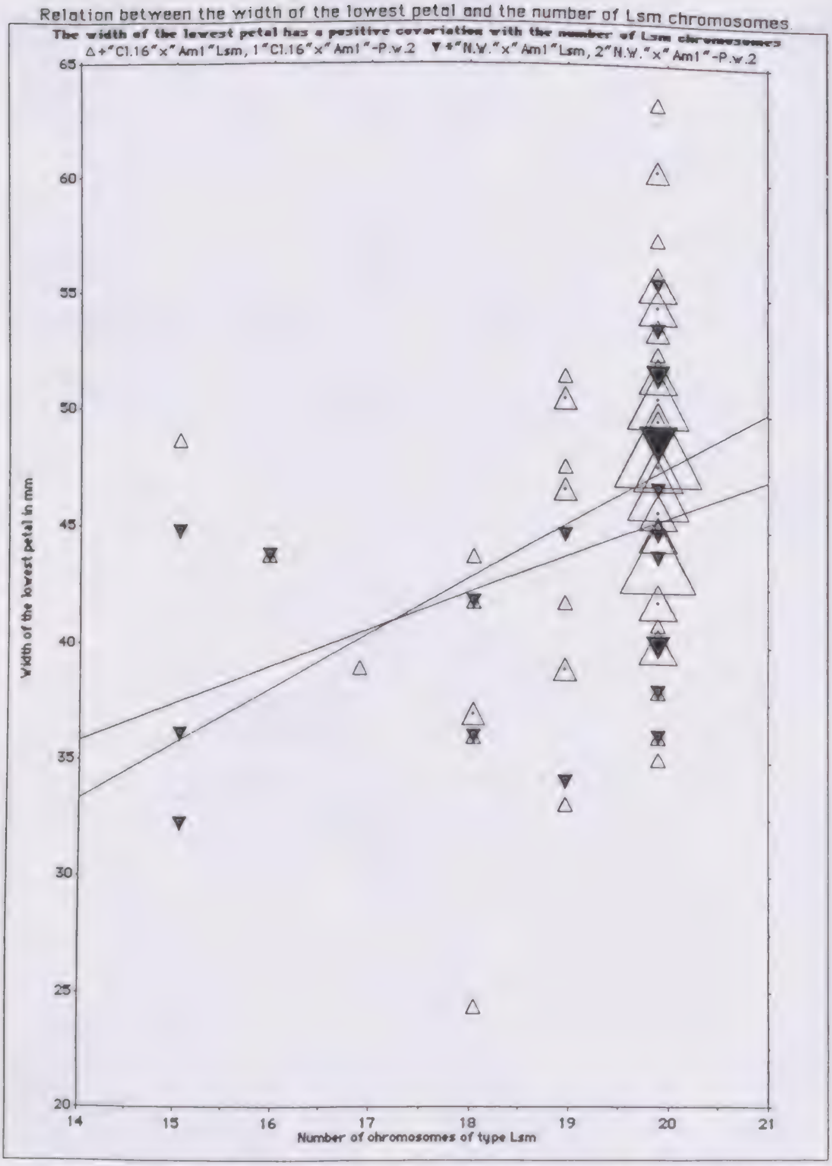

Figure 5. Graph of the width of the lowest petal correlated to the number of long chromosomes with a submedian centromere (type Lsm) in both crosses.

Table 10. Families with the highest frequencies of B chromosomes.		
Monocotyledons:	Commeliniaceae	11.3% of 240 species
	Amaryllidaceae	8.6% of 395 species
	Liliaceae	8.2% of 1769 species
	Gramineae	6.3% of 3287 species
Dicotyledons:	Begoniaceae	20.3% of 79 species
	Lauraceae	9.7% of 31 species
	Polemoniaceae	9.6% of 115 species
	Plantaginaceae	8.3% of 108 species

When Narain (1977) wrote his perspicuous paper on "Cytogenetics of garden *Amaryllis*", 22 of the 67 species were studied cytologically. Since then the number of studied species has increased to 46, especially through the work of W.S. Flory and R.F. Coulthard, Jr. (1981), M. Williams (1982) and J. Dutilh (1987).

Up to now B chromosomes have been found in seven of the 46 species of *Hippeastrum* (Table 11). This means that about 15% of the species may contain B chromosomes. These B chromosomes have, as far as is known, the same morphology and as they occur in so many species they may be of an ancient origin. Also, the almost perfect preferential segregation on the female side speaks in favour of a long and advantageous evolution of this B chromosome in *Hippeastrum*.

Table 11. B chromosomes in *Hippeastrum*.

Species	Chromosome number	Reference
H. blossfeldiae	$2n=44$ (+B)	J. Dutilh, 1987
H. calyptratum	$2n=22$ (+B)	J. Dutilh, 1987
H. forgetii	$2n=22$ (+B)	S. Arroyo, 1982
H. iguazuana	$2n=22$ (+BB)	M. Williams and T.R. Dudley, 1984
H. pardinum	$2n=22$ (+B)	G. Ising, 1989
H. psittacinum	$2n=22$ (+B) $2n=44$	J. Dutilh, 1987 " "
H. striatum	$2n=44$ (+B)	J. Dutilh, 1987

2. Preferential Segregation of the B Chromosome

Very often a plant has only one B chromosome and, as this has no homologous partner to pair with in metaphase 1, it should be lost in at least half the progeny. If there were no methods to compensate or neutralize this effect, the B should very soon get lost either by random drift or by its often deleterious effect on fertility. Therefore, all B chromosomes have got a selective advantage usually in the form of an accumulation mechanism involving a preferential segregation of the B either during meiosis or during the first or second mitotic division in the gametophyte subsequent to meiosis. For example, in some strains of *Zea mays*, the B chromosomes are maintained by nondisjunction at the second pollen mitosis (that produces the two sperms) and by the preferential fertilization of the egg cell by the sperm containing the B chromosome. Thus, there is a pollen tube competition resulting in a greater percentage of fertilization of the ovules by the pollen grains wearing the B chromosome (Roman 1947). In *Hippeastrum* there is apparently a mechanism on the female side involving a preferential segregation of the B in MI of meiosis so that the B is preferentially included in the egg cell. Too many B chromosomes in an individual may often cause a reduction in fertility (disturbances in meiosis) and vitality. That means that the number of B chromosomes in many plants rarely will exceed one or a few in mean.

In a cross where the mother plant was a B chromosome wearing hypotriploid individual, all except one out of twenty-two progeny plants had the B chromosome. Thus, together with the four triploid plants from the cross *H. pardinum* x 'Tetraploid White' ($2n$=44) there are 25 out of 26 cases where the B has come into the egg cell. This means that there is a very perfect preferential segregation of the B in the first meiotic division to that pole which will result in the egg cell. A similar preferential segregation in female meiosis has earlier been described for *Trillium grandiflorum* (Rutishauser 1955), *Lilium callosum* (Kayano 1957) and *Plantago serraria* (Fröst 1959). In none of these three cases was there such a perfect preferential segregation as in *H. pardinum* (Table 12.)

Table 12. Segregation of B chromosomes on the female side. Female with one B, male parent without B. The expected mean without preferential segregation is 0.5.

Species (author)	Progeny plants with				*n*	Mean
	0B	1B	2B	3B		
Hippeastrum pardinum (Ising 1989)	1	25	0	0	26	0.96
Lilium callosum (Kayano 1957)	16	83	1	0	100	0.85
Trillium grandiflorum (Rutishauser 1956)	37	5	238	0	280	1.74[1]
Plantago serraria (Fröst 1959)	76	183	0	0	259	0.71
Crepis conyzaefolia (Fröst 1962)	18	65	2	0	85	0.81
Zea mays (Randolph 1941)	46	19	0	0	65	0.29
Festuca pratensis (Bosemark 1954)	684	445	12	5	1146	0.42

[1]For *Trillium grandiflorum* the B chromosomes have been studied in endosperms and, as these are made up of two polar nuclei and one sperm nucleus, we would expect endosperms without B or with two B's in equal numbers giving a mean of 1.0. To be comparable with the other means 1.74 has to be divided by 2.

The two species *Zea mays* and *Festuca pratensis* are included for comparison, as they have no preferential segregation on the female side. Instead they have a directed nondisjunction at the pollen mitosis resulting in a higher frequency of B chromosomes in the progeny from crosses with B on the male side. (Table 13.)

Hippeastrum pardinum has apparently a mechanism for maintaining the B chromosomes also on the male side in contrast to *Lilium*, *Trillium* and *Plantago*, which all have mean values near 0.5. If this phenomenon depends on a mitotic non-disjunction of the B or on a pollen competition has not been studied. The fact that all three chromosome types (Lsm, Lst and Sm) are more frequently in plants having a B weighs in favour of the last explanation. From the data presented, it is likely that the B chromosome of *H. pardinum* on the female side behaves similarly to the B chromosomes of *Lilium callosum* and *Trillium grandiflorum*. This means that the unpaired B chromosome remains undivided in the first meiotic division and does not split until the anaphase of the second division. On the male side, however, there is also a significant increase of B as compared to what was expected and this may point to a directed nondisjunction at the first pollen mitosis or/and to a selective advantage of the pollen tubes with a B in reaching and fertilization of the egg cell.

Table 13. Segregation of B chromosomes on the male side. Female without B. The expected mean without mitotic nondisjunction or pollen competition is 0.5.

Species (author)	Progeny plants with				*n*	Mean
	0B	1B	2B	3B		
Hippeastrum pardinum (Ising 1989)	49	108	1	0	158	0.70
Lilium callosum (Kayano 1957)	45	55	0	0	100	0.55
Trillium grandiflorum (Rutishauser 1960)	195	215	0	0	410	0.52
Plantago serraria (Fröst 1959)	111	92	2	0	205	0.47
Crepis conyzaefolia (Fröst 1962)	31	78	2	0	111	0.74[1]
Zea mays (Randolph 1941)	32	13	5	2	52	0.56
Festuca pratensis (Bosemark 1954)	668	177	275	3	1123	0.66

[1]Fröst (1964) has shown that *Crepis conyzaefolia* has an endomitotic reduplication in early mitotic prophase which explains the increase compared to expected in this case.

3. Effects of the B Chromosome on Chromosome Number

From Table 5 it is obvious that the presence of a B chromosome has an effect on the number of all the other chromosome types. It is not easy to find an explanation to this result. If we assume that the B chromosomes are represented with the same frequency (50%) in all the types of pollen grains form the triploid plant, then the result should indicate that the B should increase the speed and/or the success of fertilization the more chromosomes there were in the pollen grain. It may be more likely that the B chromosome of *Hippeastrum* has a mechanism similar to that of *Zea mays* and *Festuca pratensis*, i.e. a directed nondisjunction at the first pollen mitosis. A cytological study of male meiosis and pollen mitosis would contribute to the solution of this problem.

4. Effects of the B Chromosome on Flower Characters

For the first cross — 'White Clone 16' x 'Am1' — there were four significant effects of the B chromosome (Table 7):

a. A positive effect on flowering times (how many times the plant has flowered.)
b. An effect on the incidence of red colour.

c. An effect on the percentage of red colour in the flower.
d. An effect on spot frequency in spotted individuals.

a. The first of these, the effect on how many times the plant has flowered, is also found to some extent in the second cross with only 22 plants. For the total material it is on the border of one star significance and it needs a larger material to establish a clear relationship, if it exists.

b. Most plants have almost white or almost red flowers. There is no clear-cut relation between the B chromosome and this main colour. Maybe the effect of B depends on its co-variation with one of the other chromosomes.

c. The one star significance for a higher percentage of red colour in plants with a B chromosome is probably accidental, as it is not significant for the total material. Part of this correlation may depend on the effect B seems to have on spot frequency.

d. It is very likely (P>99%) that there is an effect of the B chromosome on the frequency of spots in spotted plants. One of the small Sm chromosomes may also have an effect on spot frequency similar to that of the B chromosome. This is shown by the insignificant positive correlation between the number of Sm chromosomes and the spot frequency in spotted plants ($r=0.243$, $p=0.09$).

For the second cross – 'New White' x 'Am1' -- there are three effects of the B chromosome which are significant.

a. A negative effect on number of flowers per umbel. As such an effect is completely absent for the first cross with eighty individuals, it is likely that it is accidental in this small material.

b and c. Petal length and petal width are positively correlated to the number of B chromosomes. This may be an indirect effect of the strong co-variation between B and one or several of the other chromosomes with an effect on flower size. Thus, the only real effect of the B chromosome may be its positive effect on spot frequency. That this is not significant in the second cross may depend on the very small number of spotted individuals ($n=7$). For the total material it is still highly significant.

SUMMARY

A plant of *Hippeastrum pardinum* with $2n=22+B$ was pollinated with pollen from a tetraploid *H. hybridum* with $2n=44$. All four triploid progeny plants had the B chromosome. One plant of these with $2n=32+B$ was pollinated with pollen from two different tetraploid individuals and gave 22 progeny plants, of which all except one had the B chromosome. One of the plants had $2n=54+B$ and may be the result of an unreduced egg cell combined with a sperm wearing 22 chromosomes. It is supposed that there is a preferential segregation of B in metaphase I directing it to the cell which gives rise to the egg cell. The preferential segregation seems to be more perfect than similar cases earlier described.

Another triploid plant had $2n=33+B$ and was used as a pollen parent in a backcross to two white-flowering tetraploid plants of *H. hybridum*. Of 158 chromosome studied plants, 108 got one and a single plant got two B

chromosomes. Thus, also on the male side there is a significant preference for the B chromosome. The reason for this is unknown, but one explanation may be an effect of B on pollen tube growth.

A statistical analysis revealed an effect of the B chromosome on chromosome number in the progeny of the last cross. Thus, among 109 plants resulting from pollen grains having a B, none had less than 14 ordinary A chromosomes. This has to be compared to the 49 plants without a B, of which six had resulted from pollen grains having between 11 and 13 chromosomes.

A trial to correlate the presence of the B chromosome with some flower characters revealed a positive effect on petal length and petal width, probably indirectly caused by the co-variation of B and the other chromosomes. However, the small, red spots on some flowers increased remarkably in plants having a B chromosome compared to spotted plants without a B.

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HIPPEASTRUM PARDINUM CROSSED TO A WHITE *H. HYBRIDUM*: II. BACKCROSSES OF THE TRIPLOID HYBRID TO WHITE OR RED *H. HYBRIDUM*

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INTRODUCTION

In an earlier paper the chromosomes of *Hippeastrum pardinum* were described (Ising and Wide-Andersson, 1991). The plant studied had the somatic chromosome number $2n$=22+B. It was pollinated with pollen from a tetraploid *H. hybridum* with white flowers. One of the four progeny plants obtained was called "Am 1" and had $2n$=33+B. It has been used in a number of crosses both to tetraploid plants with white and with red flowers. In the first paper the segregation for the B chromosome was studied. The B went preferentially to the egg cell on the female side (almost 100%). There was also a strong tendency for a preferential segregation on the male side and possible explanations for this phenomenon were discussed. Also the relationships between the segregation for the B chromosome and some flower characters were analyzed. As the B chromosome had an indirect effect on the number of the other chromosomes, it was difficult to discriminate between the effect of these and the effect of the B on flower characters. The ordinary eleven chromosomes (A chromosomes) were divided in three groups: five long with submedian to subterminal centromeres ("Lsm"), two long with subterminal centromeres ("Lst") and four short with submedian to median centromeres ("Sm"). The B chromosome is short with a subterminal centromere and is easy to distinguish from the other three types.

CHROMOSOME DISTRIBUTION IN THE BACKCROSSES

Four different backcrosses will be dealt with in this paper. In the first two crosses the triploid "Am 1" was used as a pollen parent to two different white tetraploid plants and in the third and fourth crosses it was used on two different red tetraploid plants. In the four crosses 80, 22, 3, and 14, plants have been analyzed as to chromosome numbers. Because the third cross has only three determined plants and the mother plants in the third and fourth crosses were sister plants, these two crosses have here been counted as one (Table 1.)

Table 1. Chromosome numbers in plants from crosses between tetraploids and triploids.

Chromosome numbers	"Clone 16" x "Am 1"	"New White" x "Am 1"	"Red 5:1 & 5:3" x "Am 1"	Total
33	1	3	0	4
35	0	0	1	1
36	1	1	0	2
37+B	0	0	1	1
39	1	0	1	2
39+B	1	0	2	3
39+BB	1	0	0	1
40	8	2	1	11
40+B	6	0	1	7
40+B+Mini	0	0	1	1
41+B	9	2	1	12
42	1	3	0	4
42+Mini	0	0	1	1
42+B	12	2	2	16
43	3	2	0	5
43+B	17	3	2	22
43+B+Mini	0	0	1	1
44	4	0	0	4
44+B	15	4	1	20
44+B+Mini	0	0	1	1
Total	80	22	17	119

Four of the plants from the cross "Red 5:3" x "Am 1" have a special small chromosome called "Mini" in the table. Obviously this is inherited from the mother plant. This plant was unfortunately lost before the progeny was studied. The mini-chromosome has an almost median centromere and is about half the size of the B chromosome. As its origin is unknown it is not possible to say if it is a second kind of B chromosome related or unrelated to that from

H. pardinum or if it comes from an ordinary A chromosome.

From Table 1 it is obvious that the ordinary B chromosome is represented in most plants with 41 or more of the normal chromosomes (76 of 86 plants) while it is less often present in plants with lower chromosome numbers: $2n$=33 to 40 (13 of 33 plants.) None of the seven plants with $2n$=33 to 37 has got a B chromosome. These results have been dealt with in the first paper and will not be treated further here. As strong correlations also exist between the three different chromosome types in all the crosses of table 1, these relations have to be taken into consideration when the relationship between different flower characters and different chromosome types are evaluated. Characters, which are more or less significantly correlated to a specific chromosome group, may, for example, be studied in a selected material that does not vary in other chromosome types.

FLOWER COLOUR

The main colour of the flowers in these crosses is white or red and it is very rare to have an intermediate colour, i.e.: between 25 and 75% red colour (Figures 1-5). More such are found in the third cross as plant number XII:12 in Figure 5d, but none of them has been studied as to chromosomes. Therefore, if a plant has less than 25% red colour, it is designated as having a white main colour and if it has more than 75% red it is characterized as having a red main colour. If the main colour is defined in this way the three crosses can be summarized as in Table 2.

Table 2. Segregation in flower colour (main colour) in the three crosses. (Also, plants that have not been studied cytologically are included here.)

Percentage red colour	0-24	25-75	76-100	Total
First cross	37	4	57	98 (Figures 1 & 2)
Second cross	21	1	22	44 (Figure 3)
Third cross	4	12	44	60 (Figures 4 & 5)

In the two back-crosses to a white tetraploid *H. hybridum*, about half of the individuals have a white main colour. Many of these have red stripes as in Figures 1c-f or red spots as in Figures 1g and 1h. Such secondary colour patterns will be considered later. If the gene for red main colour comes from *H. pardinum*, all the colour pigment in that species is apparently concentrated in the spots. The triploid hybrid "Am 1" is red but still with some darker spots on the red background. If there is only one dominant main gene for red colour, this would be present in one third of the progeny that has received only one of the chromosomes wearing a colour factor from the triploid pollen parent. On the contrary, it will be present in two thirds of the progeny that

Figure 1. Plants with white main color from the cross between the tetraploid white "clone 16" and the triploid "Am1":
A. no. 11:24 with $2n$=39+BB; B. no. 11:8 with $2n$=40; C. no. III:6 with $2n$=43+B; D. no. I:43 with $2n$= 42+B; E. no. I:33 with $2n$=39+B; F. no. III:30 with $2n$=41+B; G. no. I:18 with $2n$=44; H. no. I:48 with $2n$=43+B.

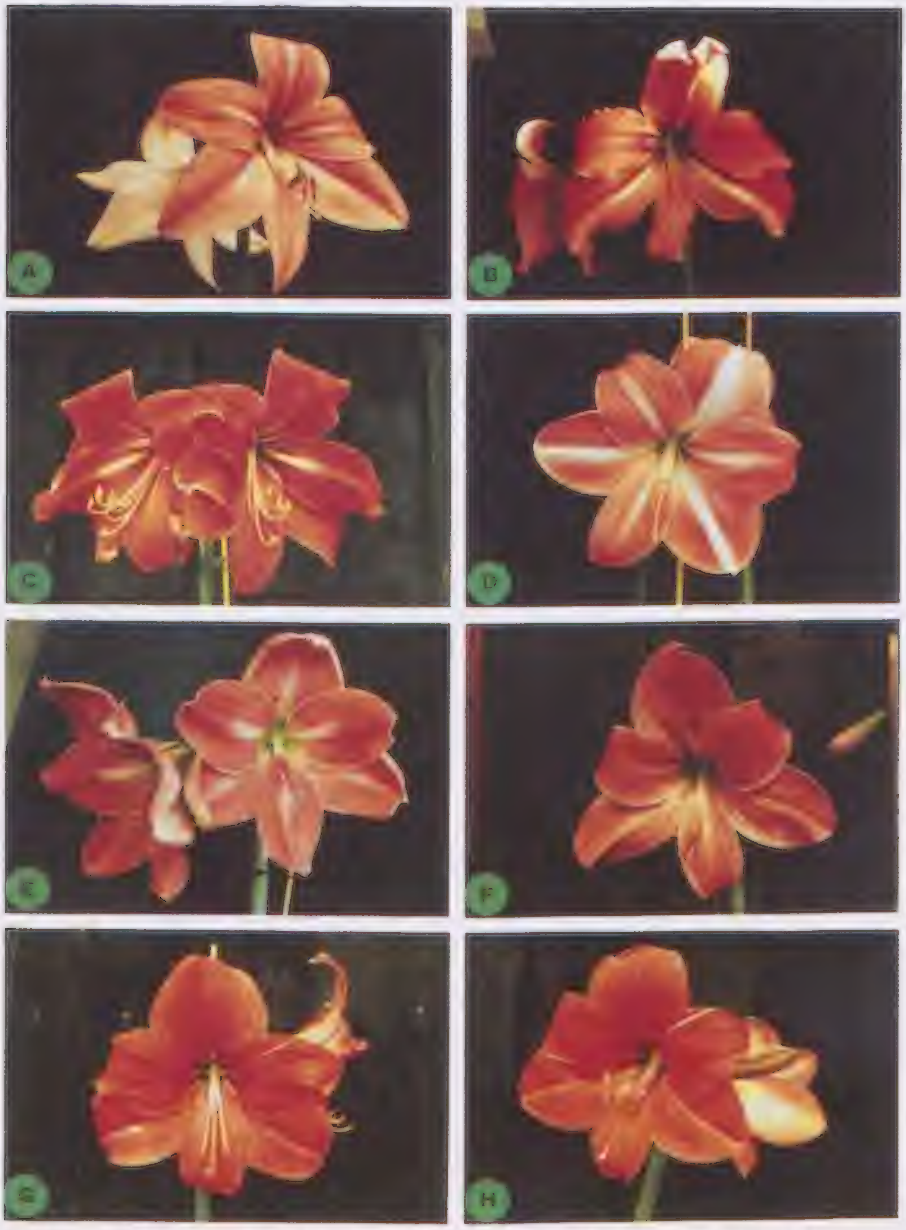

Figure 2. Plants with red main color from the cross between the tetraploid white "clone 16" and the triploid "Am1":
A. no. III:15; B. no. III:17 with $2n$=40+B; C. no. I:53 with $2n$=33; D. no. II:26 with $2n$=40+B; F. no. III:16 with $2n$=43+B; G. no. I:7 with $2n$=42+B; H. no. II:12 with $2n$=44+B.

has received two such chromosomes. Thus, if red colour is positively correlated to a specific chromosome type but not to the other types, one chromosome of this type may have the suspected gene for main colour.

To study the inheritance of red contra white colour, it may be of interest also to see if any of the minor colour effects (spots and stripes) are related to the main colour in their inheritance. Two other minor effects have also been included among the qualitative characters, namely green flower centrum and scent of the flower. All these characters are correlated to each other in Table 3, where the two first crosses are combined (n=102).

Table 3. Correlation between different colour characters and scent in the back-cross of the triploid "Am 1" to the tetraploid white *H. hybridum*. (n=102)

		Presence of spots	Spot freq. (in spotted)	Red stripes	Green centrum	Scent
Main colour (White or Red)	r	-0.220*	+0.273	-0.451***	-0.348***	-0.223*
	p	0.027	0.058	0.0001	0.0003	0.027
Presence of spots	r	-	-	+0.054	-0.036	+0.077
	p			0.588	0.722	0.454
Spot freq. in spotted	r	-	-	-0.200	-0.295*	+0.096
	p			0.168	0.042	0.516
Red stripes	r	-	-	-	+0.117	+0.070
	p	-	-	-	0.212	0.495
Green centrum	r	-	-	-	-	+0.267**
	p	-	-	-	-	0.008

It is evident that except for spot frequency, the "main colour" is negatively correlated to the other four characters. Especially red stripes and green centrum are apparently most common in white or almost white flowers.

The "main colour" in these combined first and second crosses is correlated to the frequency of the different chromosome types in Table 4. Here are also included the four characters, which were negatively correlated to main colour.

Table 4. Correlation between chromosome types and main colour as well as some minor component of colour and flower scent.

Chromosome type		Lsm	Lst	Sm	B
Main colour	r	-0.068	-0.060	+0.134	+0.180
Spot freq. in spotted	r	+0.019	+0.168	+0.243	+0.389**
	p	-	-	+0.093	+0.006
Red stripes	r	-0.059	+0.064	-0.044	+0.067
Green centrum	r	+0.171	-0.006	-0.111	-0.151
Scent of flower	r	-0.072	-0.105	-0.116	-0.074

The only significant correlation in table 4 is caused by the effect of the B chromosome on spot frequency and this has been dealt with in an earlier paper. However, there may be a positive effect on main colour by one of the Sm chromosomes, especially as none of the other two types of chromosomes are positively correlated to main colour. It is possible that one of the Sm chromosomes also has a positive effect on spot frequency. The positive, but insignificant, correlation between B and main colour may be caused by chance, since a gene for main colour in B most likely should have made all plants with a B chromosome red. Thus, the present data speaks in favour of one of the Sm chromosomes as the chromosome that is wearing the gene for "main colour".

To demonstrate how well the three different chromosome types may be distinguished from each other, a photo of the chromosomes in a tetraploid plant - I:41 with $2n$=44+B - is shown in Figure 6. In addition, drawings of the chromosome complements of six different plants are presented in Figure 7. The first of these plants (7A) is *H. pardinum* with $2n$=22+B, the second (B) is one of the triploid progeny plants "Am4" with $2n$=32+B, the following four are from the crosses in table 1 and have $2n$=44+B (C), $2n$=40 (D), $2n$=43+B (E) and $2n$=39+BB (F). A photo of the last of these, number II:24, is found in Figure 1A.

FLOWER SIZE

A number of measurements have been performed on the first flower each time a plant has flowered. A mean of these measurements is used for each individual. Some measurements may be divided into sub-characteristics: for example, flower length is divided in tube length and length of the uppermost petal. For this petal as well as for the lowest petal, the width has been measured. These are called P.w.1 and P.w.2 in Table 5. Also, the difference P.w.1-P.w.2 is given in the table as some individuals have a big difference between the two petals. Table 5 also includes the length of the longest pedicel and the length of the longest spathe valve. Short pedicels will sometimes give more upright flowers and long pedicels will probably give more down-

Figure 3. Plants with white or red main color from the cross between the tetraploid "New White" and the triploid "Am1":
A. no. IX:35 with $2n$=33; B. no. VIII:10 with $2n$=40; C. no. IX:10 with $2n$=42+B; D. no. VIII:16 with $2n$=40; E. no. IX:1 with $2n$=42 (see also figure 8); F. no. VIII:14 with $2n$=43+B; G. no. IX:32 with $2n$=33; H. no IX:24 with $2n$=41+B.

Figure 4. Red flowers from crosses between the red tetraploids "5:1" and "5:3" and the triploid "Am1" (most plants are undetermined as to their chromosome number): A. no. XII:4; B. no. XII:17; C. no. XIV:18; D. no. XIV:14; E. no. XIV:12 with $2n$=39+B; F. no. XIV:7 with $2n$=40; G. no. XIII:6 with $2n$=42+ Mini; H. ho. XIII:7 with $2n$=40+B+Mini.

bending flowers. Long and green spathe valves will sometimes make the flowers more attractive as in Figure 8, which shows four stages from a round bud to an open flower in number IX:1. The special petal form in this plant is probably a prerequisite for the almost globose, big buds.

It is interesting to see how strong the positive correlation is between tube length and pedicel length in this material (Figure 9). the reason for this may be that they are located almost next to each other and are influenced by the same concentration of growth hormones. This concentration will certainly vary between different plants also for genetic reasons.

Table 5. Correlation between some flower measurements and number of the different types of chromosomes for the crosses White *H. hybridum* x "Am 1" (n=102).

Characteristics		Type of chromosomes: Lsm	Lst	Sm	B
Flower number	r	-0.046	+0.040	-0.085	-0.143
	p	-	-	-	0.152
Flower length	r	$+0.281^{**}$	+0.167	+0.154	+0.106
	p	0.004	0.093	0.123	-
Petal length	r	$+0.261^{**}$	+0.168	+0.169	+0.104
	p	0.008	0.092	0.090	-
Tube length	r	$+0.239^{*}$	+0.093	+0.028	+0.065
	p	0.015	-	-	-
Petal width 1	r	$+0.425^{***}$	+0.184	+0.059	+0.119
	p	0.0001	0.064	-	-
Petal width 2	r	$+0.386^{***}$	+0.118	+0.077	+0.030
	p	0.0001	-	-	-
P.w.1-P.w.2	r	$+0.303^{**}$	+0.191	+0.014	+0.181
	p	0.002	0.054	-	0.069
Pedicel length	r	+0.180	-0.086	-0.029	-0.069
	p	0.070	-	-	-
Spathe valve length	r	$+0.226^{*}$	+0.115	+0.117	+0.066
	p	0.022	-	-	-

Significant correlations are only found in the first column with chromosomes of the type Lsm. As there are five such big chromosomes, constituting about 60% of the total genome, it is not surprising to find many genes for quantitative characters associated with those chromosomes. Both the components in flower length, i.e.: petal length and tube length, as well as petal width for the highest and lowest petal and the difference between the two petals are highly correlated to the number of this type of chromosomes. That also the length of the spathe valves, the mission of which may be to protect the young flower buds, is correlated to flower size is not surprising. Naturally, it may be practical if genes for size of spathe valves are located on the same chromosome as the main genes for flower size.

If genes for the difference in width between the highest and lowest petal (P.w.1 - P.w.2) also are located on the same chromosome as the main genes for flower size may be studied by correlating the difference to the size characters. The correlation between flower length and the difference in petal width is $r=+0.429^{***}$, which is almost as good as the correlation between flower length and the width of the highest. ($r=+0.541^{***}$) or lowest petal ($r=+0.456^{***}$.) It is apparent that this difference increases when the width of the two petals increases with flower length. There seems to be an almost constant relationship between these characters.

SPECIAL RELATIONSHIPS

During the study some special relationships have been found which are more or less difficult to explain. Three such will be demonstrated here with figures:

1. The bigger the difference in width between the two petals (P.w.1 - P.w.2), the earlier in the season the plants will flower. This correlation is very significant ($r=+0.368^{***}$, $p=0.002$) if only plants with 40-44 chromosomes and a B chromosome are counted ($n=71$). Figure 10.

2. Plants with red stripes, especially long, red stripes, flower more often than do other plants ($r=+0.292^{**}$, $p=0.003$.) Figure 11.

3. Plants flowering late during the season seem to flower more often. This phenomenon is studied only for plants which have flowered at least two times during the years ($n=94$, $r=+0.268^{**}$, $p=0.010$.) Figure 12.

It is possible that such correlated characters depend on genes located in the same chromosome in the present material. In any case, it is difficult to find any physiological explanation for the first two of these correlations. The third may reflect the fact that some bulbs often give two flower stalks the same year and, therefore, flower later.

CONCLUSIONS AND FUTURE PROSPECTS

It was never planned from the beginning that this material should grow out to a research project. However, by and by it has grown and flowered and I have tried to measure and take photos of the flowers. Now, when more than a hundred individuals from one type of cross have flowered, I felt it worthwhile to study it by statistical methods. Naturally, if it had been planned more

gure 5. White, red and intermediate flowers from the crosses between the tetraploid red "5:1" or "5:3" and the triploid "Am1" (most plants are not studied as to chromosome numbers):

A. no. XIV:9; B. no. XIII:12; C. no. XIII:4 with $2n$=44+B; D. no. XII:12; E. no. XIII:10; F. no. XII:2; G. no. XIII:2 with $2n$=44+B+Mini; H. no. XII:8 with $2n$=43+B.

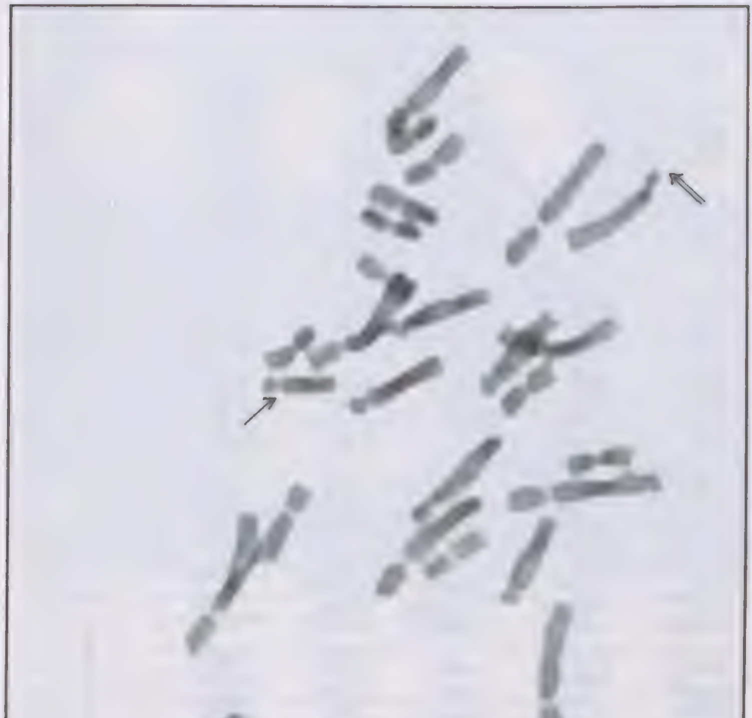

Figure 6. The chromosomes of a tetraploid plant no. I:41 with $2n=44+B$. One arrow points on the B chromosome and two arrows with parallel lines on two of the four chromosomes 6 which have

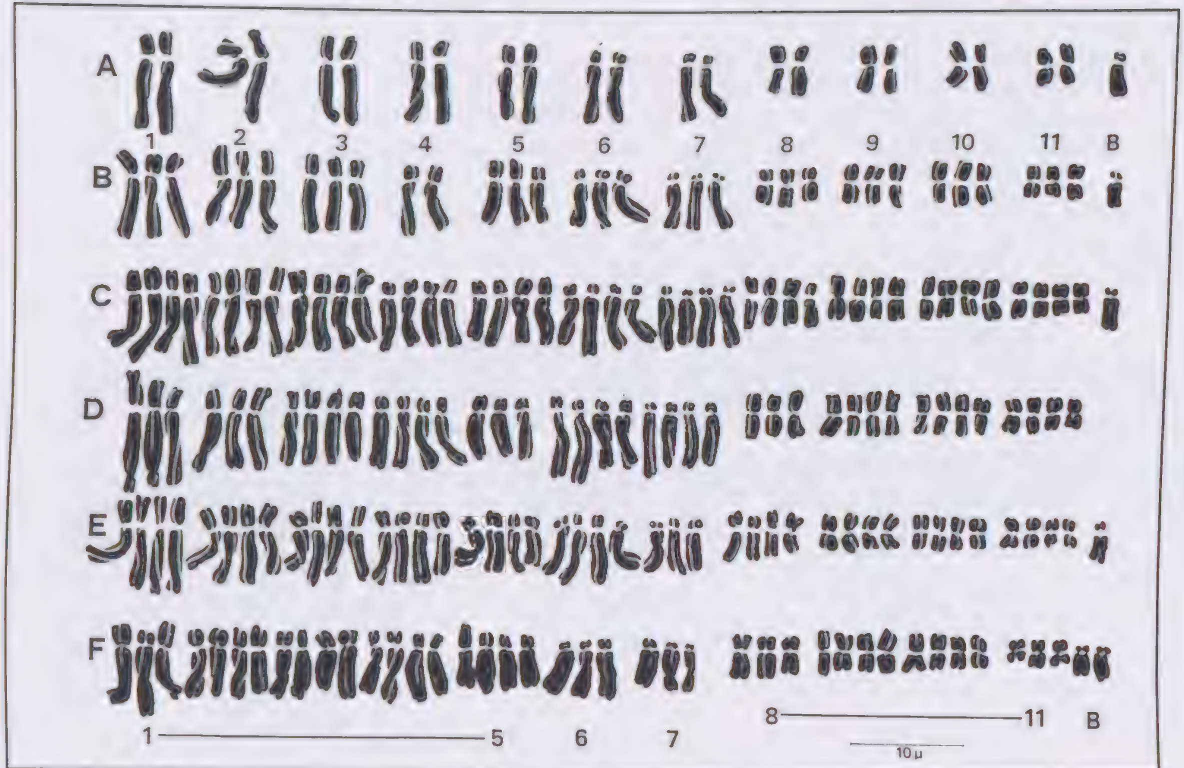

Figure 7. Drawings of the chromosome complements of six different plants: A. the diploid *H. pardinum* with $2n$=22+B; B. the triploid plant 'Am 4' with $2n$=32+B; C-F: plants from the crosses between tetraploids and the triploid 'Am 1'; C. $2n$=44+B; D. $2n$=40; E. $2n$=43+B; F. $2n$=39+BB (no. II:24, see photo 1A).

Figure 8. Above are four photos of plant no. IX:1 ($2n=42$) showing long spathe valves and four steps in the opening of the flower. Notice the peculiar shape of the petals and the almost globose bud just before it opens.

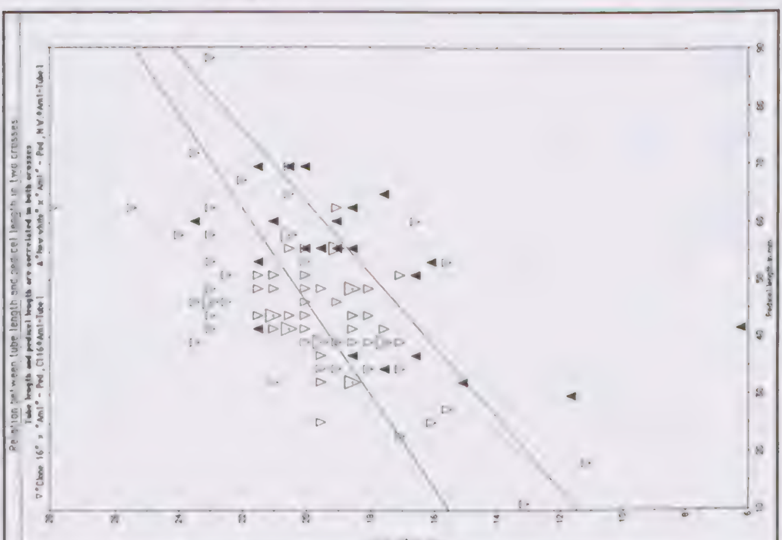

Figure 9. Tube length in relation to pedicel length in the two different types of crosses: white *H. hybridum* x 'Am 1' (n=80) and red *H. hybridum* x 'Am 1' (n=22).

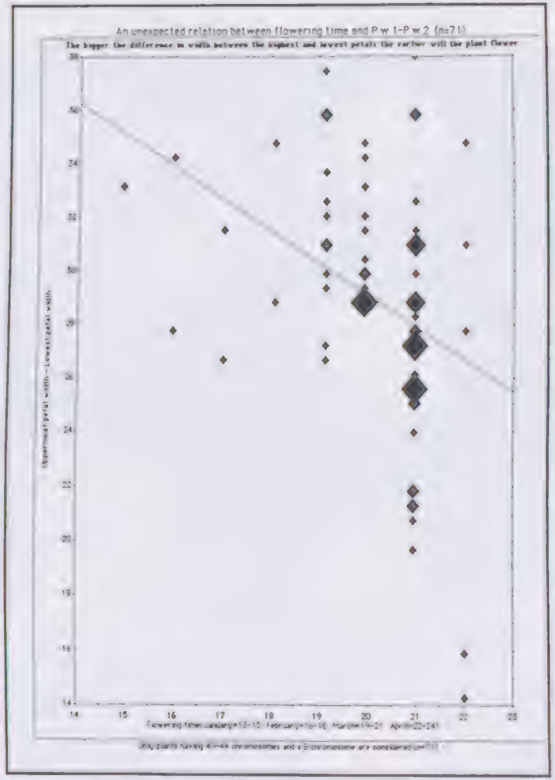

Figure 10. Plants with a big difference between uppermost petal width and lowermost petal width (P.w.1 - P.w.2) seem to flower earlier in spring than plants with a smaller difference do.

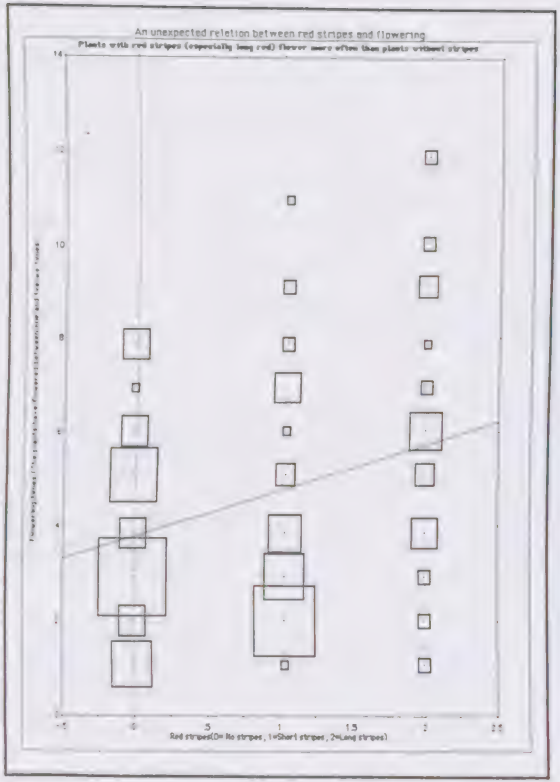

Figure 11. Plants with red stripes, especially long, red stripes, seem to flower more often than plants without red stripes on the flowers.

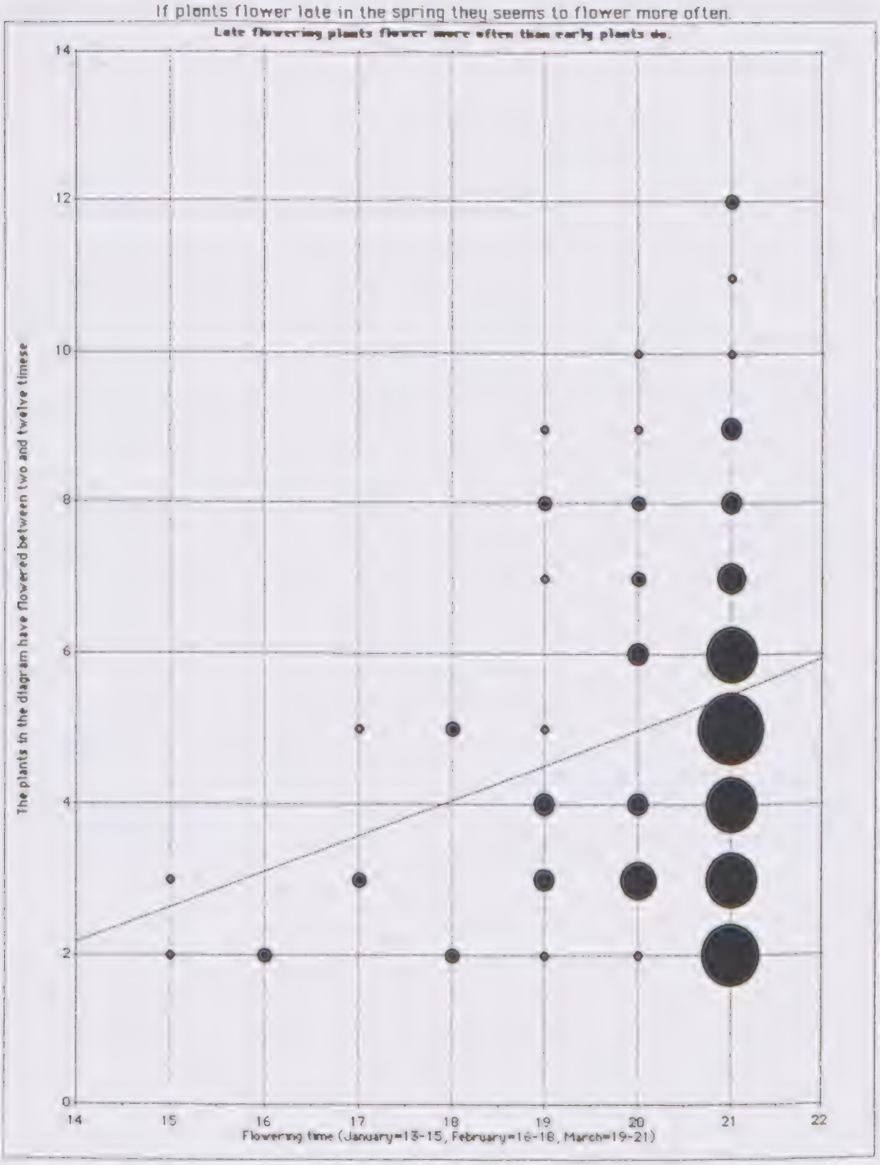

Figure 12. Plants which flower late during the spring seem to flower more often than early plants.

carefully, if all plants had been cultivated under similar conditions and if I had studied the chromosome numbers of more plants in the beginning before some of them were dead or given away, the results would have been more exact and more conclusions could have been reached.

With the present day methods of chromosome staining (banding techniques), it is possible that morphologically similar chromosomes within the three types can be distinguished from each other. Such a study on a larger body of material would certainly give more reliable and more valuable results.

It is also of interest to compare the results with similar results from studies in an African genus, *Cyrtanthus*, which I performed during the sixties (Ising, 1969.) In *Cyrtanthus parviflorus* the gene for red flower colour is located in the smallest chromosome of the complement (2n=16.) As we have seen, it is likely that the gene for main flower colour in *Hippeastrum* is located in one of the small chromosomes of type Sm. Therefore, when more genes have been placed in the different chromosomes, it will be possible to compare and draw conclusions as to the relationship between the chromosomes of *Hippeastrum* and *Cyrtanthus*.

It would be very interesting to try by modern technique to hybridize the *Hippeastrum*-like *Cyrtanthus elatus* (earlier *Vallota speciosa*) with some diploid species of *Hippeastrum*. If such hybrids later are made tetraploid by colchicine treatment of germinating seeds, they will most likely become fertile.

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PROPAGATION OF *HIPPEASTRUM* FROM FLORAL TISSUES BY *IN VITRO* CULTURE

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In 1977 and 1978 *Hippeastrum hybridum* floral tissues were examined for their ability to produce plantlets from calli or direct organogenesis from various regions of the inflorescence in aseptic culture. The use of floral tissues offers several advantages over other sources: it does not require the destruction of the bulb; explant material may be obtained at the time of flowering, ensuring propagation of material true-to-type; desirable seedlings may be propagated as soon as selected; above-ground parts are relatively free of soil-borne contaminants (2,4).

Hippeastrum hybridum 'Apple Blossom' flowers were excised from mature bulbs at two stages: in December and in February following natural cooling of the bulbs outdoors. Bulbs had accumulated about 280 hours of chilling below 7°C in December, while those in February had undergone about 870 hours of chilling. Floral scapes from the bulbs cut in December were about 2.3cm in length, with a range of 1.2 to 2.6cm. Scapes from February cuttage ranged from 4.7 to 7.7cm in length, with a mean of 6.0cm.

Scapes were surface-sterilized in a 0.5% solution of sodium hypochlorite in water with 2 drops of "Tween 20" surfactant per 100ml. After 10 minutes, scapes were rinsed 3 times with sterile, distilled water. Agar-based media were used in 25 x 150mm pyrex tubes and cultures were given 16 hours of light and 8 hours of darkness each day. Cool white fluorescent tubes provided a radiant flux of 94 microeinsteins $m^{-2}sec^{-1}$, and temperatures were kept at 21°C.

Petal, anther, filament, style, pedicel, and ovary tissues were excised from the surface-sterilized flowers and placed on various media using Murashige and Skoog's high salt medium (3) as the basal medium. Growth promoting substances added included (in mg per liter): meso-inositol, 100; adenine sulfate$\cdot$$2H_2O$, 80; thiamine HCl, 0.1; pyridoxine HCl, 170; sucrose, 25,000; bacto-agar, 6,000. The pH was adjusted to 5.7 prior to autoclaving 15 minutes at 121°C. The medium was supplemented with napthaleneacetic acid (NAA) at 0, 0.5, 1.0, 5.0, or 10.0mg/l and kinetin or benzylaminopurine (BA) at 0, 0.5, 1.0, 5.0 or 10.0 mg/l in all possible combinations. Four replications were used per treatment.

Slices of petal tissue measuring 3mm wide were taken from flowers perpendicular to the long axis and place distal end down on medium. Squares of petal tissue 8 x 8mm were placed on the medium, but rolled up, causing

desiccation. Anthers were removed from filaments and placed horizontally on the medium. Ovaries and pedicels were placed intact, distal side down on medium in December, but they were kept separated in the February cultures, cut across the long axis into slices about 2mm thick and placed distal side down on media.

RESULTS

Cellular enlargement of the horizontal slices of petal tissue resulted in about a three-fold size increase. Tissues remained alive for more than 9 months, but did not form calluses or plantlets. The anthers dehisced along the sutures after 10 days of culture, but pollen did not shed. Specks of yellow-green callus were produced at the ends of filament and style segments on media supplemented with NAA in the presence or absence of kinetin. Callus could not be increased even on media supplemented with 10% coconut milk. Increase of the callus was unsuccessful on media supplemented with 2,4-D, 2mg/l; kinetin, 1mg/l or coconut milk, 10% by volume, as was reported by Bapat and Narayanaswamy (1).

Pedicel and ovary explants from December flowers initiated plantlets after 32 weeks in culture. 52 plantlets were obtained from 7 original explants. Plantlets formed on the inside of the ovary wall and on the placentas. This occurred when NAA and BA concentrations were 1.0 and 10, 2.0 and 5.0, and 2.0 and 10mg per liter, respectively.

Pedicel tissues from February flowers were more productive than ovary tissues. Plantlets formed on pedicel explants from inner tissues at the proximal ends. Optimum NAA and BA concentrations were the same as for the ovary-pedicel explants.

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OFF-TYPE PLANTS OBTAINED FROM CALLUS CULTURES DERIVED FROM PEDICELS OF *HIPPEASTRUM HYBRIDUM* 'PINKSTERFLOWER'

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Explants of cross sections of pedicels of 'Pinksterflower' *Hippeastrum* cultured in 1977 on Murashige and Skoog high salt medium supplemented with 2,4-D at 2ppm and kinetin at 1ppm were grown to flowering in a greenhouse during 1978 and 1979 and have flowered each year since. Two types of flowers that differ from those of the original clone were obtained – one that is essentially a much smaller version of the original and the other is completely different and about 2/3 the size of flowers of the original clone.

'Apple Blossom' cultured under the same conditions produced plants that appear identical to the clone from which the explants were taken. The illustrations show the two kinds of "off-type" flowers and a comparison with a normal size 'Apple Blossom' plant obtained from callus cultures. (The labels erroneously refer to "peduncle", but the tissues were from pedicels near the ovaries of the flowers.)

Figure 1. [upper left] Off-type plants of 'Pinksterflower' from pedicel tissue culture.

Figure 2. [right]
A normal size 'Apple Blossom' plant (left) and dwarf 'Pinksterflower' (right), both from derived from tissue culture.

Figure 3. [upper right]
Half size plants of 'Pinksterflower' from pedicel tissue culture.

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RAPID PROPAGATION OF *HIPPEASTRUM* BULBLETS BY *IN VITRO* CULTURE

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Many ornamental bulbous plants in Amaryllidaceae, Iridaceae, Agavaceae and Liliaceae are slow to offset naturally in those cases where offsets occur, and some good horticultural selections rarely produce offsets (4). Many *Hippeastrum* species and hybrids have been reluctant to offset, and the species, especially, may be difficult to maintain outside their native environments. A method of increasing vegetative propagation is desirable and this study was aimed at that objective.

EXPERIMENT 1

In 1979 shoot apices or bulblets of *Hippeastrum hybridum* 'Apple Blossom' were obtained from scale-stem fractions maintained in a water-saturated atmosphere (3,5). Mature bulbs of flowering size (20 to 25 cm circumference) were the source of at least 40 fractions per bulb with bulblets averaging 2.5 per fraction after 3 weeks. The small bulblets were about 1.5 to 2mm in diameter and about 2.0 to 3.0mm long at this time. The small bulblets were excised from the scale-stem fractions, surface-sterilized by immersion for 10 minutes in a solution of 0.5% sodium hypochlorite in water with 2 drops of the surfactant "Tween 20" added per 100ml. Following immersion the bulblets were rinsed 3 times in sterile, distilled water. They were then placed on nutrient agar in 25 x 150mm pyrex tubes closed with metal closures. The tubes were maintained under cool white fluorescent lights providing a radiant flux of 94 microeinsteins $m^{-2}sec^{-1}$ for 16 hours in each 24 hour period with 8 hours of darkness. The temperature was about 21°C.

The culture medium for all experiments contained Murashige and Skoog's inorganic salts (2) and (in mg per liter): meso-inositol, 100; adenine sulfate·$2H_2O$, 80; thiamine HCl, 0.1; pyridoxine HCl, 0.5; nicotinic acid, 0.5; glycine, 2.0; $NaH_2PO_4 \cdot H_2O$, 170; sucrose, 25,000; bacto-agar, 6,000. The pH was adjusted to 5.7 prior to autoclaving for 15 minutes at 121°C. Auxin supplements to the basal medium were: napthaleneacetic acid (NAA); indoleacetic acid (IAA), 4-chlorophenoxypropionic acid (4-CPA), or 2,4-dichlorophenoxyacetic acid (2,4-D) at 0, 0.50, 1.00, 2.00, or 4.00mg per liter. Cytokinins supplemented to the basal medium included the following: kinetin, 6(8,8-dimethylalylamino purine) (2iP), or 6-benzylaminopurine (BA) at 0, 0.5, 1.0, 5.0 or 10.0 mg/l. Comparisons made were NAA, kinetin; NAA, 2iP; NAA, BA; IAA, kinetin; IAA, BA; 4-CPA, BA; 2,4-D, kinetin and 2,4-D, BA. Comparisons were also made between NAA at 0, 0.5, 1.0, 2.0 or 4.0 mg/l and

BA at 0, 0.5, 1.0, 5.0 or 10.0 mg/l. All possible combinations were made, using 4 replications per treatment.

EXPERIMENT 2

Bulblets 5 to 6 mm in diameter were halved or quartered longitudinally and placed on the basal medium supplemented with NAA at 0, 0.5, 1.0, 2.0 or 4.0 mg/l and BA at 0, 0.5, 1.0, 5.0 or 10.0 mg/l. All possible combinations were made, using 4 replications per treatment.

RESULTS

The addition of auxins and cytokinins to the basal medium on which entire bulblets were cultured failed to promote offset formation over 16 weeks. All bulblets developed roots and leaves in a normal manner regardless of the type or concentration of growth regulator employed. Hussey (1) reported that medium supplemented with BA at 2.0mg/l caused bulblets to produce 1 to 3 offsets.

Bulblets that were halved or quartered produced single bulblets from each fraction. The new bulblets attained the size of the original bulblet in the 10th to 12th week after cutting. Growth regulators did not produce any differences in the growth rates of the new bulblets nor in numbers produced that were significant.

Each large bulb originally cut into scale-stem fractions, with new bulblets subsequently halved or quartered produced about 100 new bulbs. The cuttage could be repeated every 10th or 12th week with a theoretical increase of in excess of 25,000 bulblets within a year after the mother bulb is cut. This would represent about a 250-fold increase over the numbers resulting from the scale-stem fraction method of cuttage.

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Hybridizing Double *Hippeastrum* (Amaryllis)

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For the past 12 years I have devoted much time to hybridizing double *Hippeastrum*, crossing the best of the modern hybrids with good doubles stock. I preferred the use of commercial hybrids which had rudimentary petaloids, "bearded" flowers, as seed parents, since most double flowers have undetectable or non-functional stigmas. It is interesting that the late Henry vanWoesik, the president of Ludwig Amaryllis Company, of Hillegom, Holland, indicated that he discarded seedlings that tended to be bearded. Everyone to his taste, I suppose.

An acceptable percentage of the seedlings from such crosses were double, although some of the singles were very beautiful in their own right. After some 3 or 4 years of evaluating seedlings, I selected ones that I considered worthy of increase. For multiplication I used an adaptation of the "scale-stem" method of bulb cuttage described in Traub's **Amaryllis Manual** and adapted by Dr. Ed O'Rourke of the Horticulture Department at Louisiana State University (LSU), Baton Rouge, LA, for producing very small bulblets that were virus-free when excised from the parent material. This method involves placing the cuttage from the surface-sterilized bulbs into sterile jars containing sterile water to maintain the humidity at a saturation level. Such cut pieces will usually produce small bulbs large enough to be seen in about 2 to 3 weeks, and large enough to be handled as small potted plants after about 25 weeks. This method has been very successful for me, and the jars containing the pieces of bulbs are kept under fluorescent lights on a plant stand in my den.

Following removal of the small bulbs from the jars, they are placed in a potting medium in styrofoam boxes used to transport tropical fish. These boxes are about 12 inches deep and about 18 inches square. Bulbs can be grown in these boxes until blooming size with proper spacing and, by inverting other boxes over the tops, the bulbs can be protected from cold. Many of my plants were exposed to 6°F during an unusual "100 year" freeze in December of 1989 and most survived, even though many were not much larger than 1 to 2 inch diameter bulbs.

I have had much help from others in my efforts to produce double amaryllis and I want to acknowledge their gracious help. Len Doran and C.D. Cothran of California have been generous to a fault, John Deme of North Carolina had been a willing cooperator, and Ed O'Rourke of LSU and Mrs. Walter Latapie of New Orleans, Louisiana, have helped in many ways. Incidentally, Mrs. Latapie and her late husband produced a fine double white amaryllis some years ago.

I have some really encouraging results to date and am trying to get sufficient numbers to allow trials in other areas, but all are welcome to visit and see these in my garden. The best blooming time here is from April 1 to May 15.

Figures 1-4. Double seedlings.

1. Seedling #5.

2. Double seedling.

3. Double Record.

4. A picoteed double.

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Some Observations on Increase of *Hippeastrum hybridum* Bulbs by Cuttage

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Six bulbs, about 24-26cm in circumference, of the *Hippeastrum* clone 'Wedding Bells' were cut into "scale-stem fractions" according to the method of Traub (1935) and placed into fruit jars in a water-saturated atmosphere and maintained under fluorescent lights (cool white tubes providing about 150 foot-candles of illuminance at jar level) for 16 hours daily with 8 hours of darkness. The temperature was near 21°C under the lights. When bulblets developed to ¼ inch in diameter, they were removed and planted in a greenhouse bed containing 3 parts sand and 1 part vermiculite. Scale-stem fractions were returned to the jars, where they made additional bulblets. Small bulblets were large enough to be removed about one month after they were placed into the jars in early May, 1971, and additional bulblets were removed and planted in the greenhouse until September, 1971. Bulbs were grown and fertilized intermittently with soluble fertilizer at about 300ppm concentrations with equal parts of N, P, and K. Fertilizer was applied every fourth watering. In October, 1972, plants were removed from the greenhouse bed and dried. At that time the numbers and sizes of bulbs were recorded. The older bulbs were about 16 months old at the time of the counting and the youngest about 13 months old.

***Hippeastrum hybridum* 'Wedding Bells' bulbs from cuttage.**

Size (Inch diameter)	Number of Bulbs
3 or over	(These show flower scapes) 5
2 3/4	2
2	10
1 3/4	5
1 1/2 - 1 3/4	10
1 1/4 - 1 1/2	18
1 - 1 1/4	30
1	23
3/4	10
1/2	8
3/8	1
Total	122
Average per bulb	20.3

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Traub, H. 1935. Propagation of *Amaryllis* by Stem Cuttage. **Herbertia** 2:123-126.

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Below: Figures for "The Amaryllis (*Hippeastrum*) as a Cut Flower" by A.J.M. Van Leeuwen & J.C.M. Buschman. The text begins on page 93.

▲ Figure 1. 'Cinderella'

▲ Figure 2. 'Rilona'.

Right: ▸
Kenneth E. Mann, 1991 Herbert Medal winner.

(Figure 4 for "Ken Mann: An Autobiography" by Dr. Mann, continued from page 128.)

Photo taken by Dennis Litman, December, 1990.

The Reasons for Classifying in Divisions: A Paper Presented at the World Conference, Perth, Australia, in September, 1988

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It is not the intention of this paper to examine the procedures of judging, but in explaining the placement of flowers and plants into the various divisions to which they are allocated a clearer picture of what a judge is looking for on a show bench emerges. The early botanists when studying the wild *Hippeastrum* species of South America separated them into five divisions (subgenera) according to the flowering structure and growing habits of the particular type. The five divisions are as follows:

Macropodastrum — *elegans* group. These are set apart from the rest primarily because they have very long trumpet-shaped flowers.
Lais — *striatum* group.
Amaryllis — *puniceum* group.
Omphalissa — *aulicum* group.
Sealyana — *reticulatum* group.

In similar manner the cultivated *Hippeastrum* are divided into groups having the same flower structure and growing habits.

The classifications call for nine separate divisions. It will be noted that divisions 4 and 5 have been subdivided into divisions 4A, 4B and 5A, 5B. It may be possible in the future with further breeding to further subdivide divisions, possibly the doubles and orchid flowering divisions. The aim of breeders over the last 100 years has been the production of wide open, large flowers. They have been most successful, but in the search of solid, single colours many beautiful pastel toned flowers must have been discarded; this is a great pity. Now these pastel colours are greatly appreciated by the general public. Of course, along the way some beautiful mono colours have appeared that were not quite up to the desired standard of the breeder and were too good to discard. These are the types that appear in the B divisions. On careful study of the wording of the divisions on the following pages, this word picture comes clearly into focus and these types of flowers are easily recognizable.

Just after World War II there were 46 species known to exist; 22 of these are in cultivation in the United States of America. Today there are 80 known species, not all under cultivation. Most are endangered species due to heavy land clearing and the attacks of grazing animals (pigs, goats, cattle, etc., including man.)

STANDARDS FOR JUDGING *HIPPEASTRUM*

Hippeastrum are classified in nine divisions on the basis of the chief characteristics of each group. Further sub-divisions may be made within each of the nine divisions. Each division contains many varieties. This form of classification is necessary as the foundation for exhibition schedules and as the basis for grouping by *Hippeastrum* breeders. Familiarity with the flower and its parts is necessary to intelligent evaluation. In order to simplify the classification, the nine divisions of cultivated *Hippeastrum* have been arranged in numerical order with a brief description of the distinguishing characters of each.

DIVISION 1 (D.1)

Includes all the cultivated wild *Hippeastrum* species, sub-species, varieties and forms. Size can vary from small to large florets and two or more florets are acceptable.

DIVISION 2 (D.2)

Long trumpet types. The whole flower is very long and trumpet shaped, similar to the Easter Lily. The pedicels are relatively long and the flowers are distinctly drooping. The tepal tube is very long, 11.5-14cm. Colour of flowers varies from pure white to white striped with pink. Size of the florets is 10cm and upwards in width.

DIVISION 3 (D.3)

Belladonna type hybrids. The flowers are much shorter than in division 2 and gracefully drooping. The pedicels are long, the tepal tube less than 10cm in length. They show the influence of species with the formal flower structure of *Hippeastrum puniceum*, *H. vittatum* and others. The size of flowers is 12cm and upwards in width.

DIVISION 4 (D.4)

Reginae type hybrids. The pedicels are shorter than in divisions 2 and 3. Tepal tube less than 5cm in length. The flowers are slightly drooping, horizontal or slightly upright and are moderately open faced. When viewed sideways, the flower length exceeds 10cm. The tips are rounded or slightly pointed. There are two sub-divisions in *reginae*. D4A — markedly imbricated type. The tepalsegs overlap 3/4 or more of their length. Tips of segments are rounded or slightly pointed. D4B — this is the less imbricated type. The tepalsegs overlap less than 3/4 of their length. The segments are sometimes reflexed. The tips are rounded or pointed. Size of the florets: 14cm and upwards in width.

DIVISION 5 (D.5)

Leopoldii type hybrids. The flowers are similar to those of division 4 except the flowers are wide open and flat in form. When viewed from the side, the

length must not exceed 10cm. There are two sub-divisions in this division. D5A — the tepalsegs are imbricated almost their entire length. The tips are rounded. D5B — the flowers are similar to D5A, except the segments are less imbricated. The tips are rounded or slightly pointed. Size of florets: 15cm and upwards in width.

DIVISION 6 (D.6)

Orchid flowering type. The tepal segs are not arranged according to the usual flower pattern. They are variously shaped, twisted or extremely reflexed. Size can vary from small to large florets and two or more florets are acceptable.

DIVISION 7 (D.7)

This division includes the semi-double and fully double forms of hybrids under culture. The flowers have two, three or more rows of segments, each segment narrowing and shortening toward the centre of the flowers. There may be petaloid "ears" in the centre. Size of florets: 14cm and upwards in width. The size of double *Hippeastrum* is generally 28 to 38cm in height, however, they do have longer scapes at times.

Characteristics: Generally about 90% of the doubles will have two florets to the scape. The first floret will open to near maximum before the second one opens. Never should the judges expect to find less than two florets on a scape. Also, the florets might not have a normal pistil and pollen anthers.

The entry can be judged as perfect when it has two florets if one floret is open and the second in bud or starting to open. In cases where the first floret passes its peak before the second reaches its peak, this flower should not score a blue ribbon. Care should be exercised not to judge a twin ovary flower as a double and also not to be fooled by some freak flowers which can have up to 12 petals.

DIVISION 8 (D.8)

Miniature type hybrids. Distinctly dwarf statured types, including various flower forms. The flowers harmonize with the smaller scape diameter and height. Example: Gracilis hybrids. Size of florets: maximum width 12cm. These *Hippeastrum* should not be confused with *Habranthus, Cyrtanthus*, etc., sometimes called "miniature *Hippeastrum*".

DIVISION 9 (D.9)

Unclassified hybrids. Meritorious hybrids, etc. that cannot be placed with certainty into any preceding division. Size of bloom and length of scape can vary.

The flower form and structure make up the chief difference between *reginae* hybrids (D.4) and *leopoldii* hybrids (D.5). The *reginae* flower is moderately open faced but not flat. The *leopoldii* flower is a wide open, flat

form. Familiarity with the divisions of cultivated *Hippeastrum* is necessary to intelligent evaluation. Conformity to division standards is of first importance in placement of entries in *Hippeastrum* shows. *Hippeastrum* can be judged for flower structure and flowering habit by division standards only.

Figure 1 (above). ('Paynes Best' x 'Apple Blossom') #5, a D.5 type with light burnished-orange segments and white, picoteed edges.

Figure 2 (above, right). Don Guthrie's double white (cream-yellow), division 7.

Figure 3 (right). DIVISION 7 — A nine-inch, double, red *Hippeastrum* displayed by its hybridizer, Norma Hay, in 1990.

All photos by the Larssons.

NOTES ON *HIPPEASTRUM* CULTURE

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The culture of *Hippeastrum* (Amaryllis) has been known to me since I was a boy. My mother grew an improved *H.* x "Johnsonii" hybrid which I still have in my collection. Her culture method was to use wood-chips, charcoal and sand from the wood-heap with added crumbled cow manure — a good, open mix, essential for happy, healthy bulbs.

A move to the city in 1967 with 5 old faithfuls was the beginning of my collection. My wife Les bought me bulbs from the eastern States and with these I began hybridizing. However, the season of 1977 brought problems of *Stagonospora curtisii* to the extent of nearly wiping out my collection. Les wrote to the American Plant Life Society (APLS) using the address found in the front of the "Amaryllis Manual" by H.P. Traub. We joined the Society December 7, 1977, and so began friendships with growers who have taught us the culture of *Hippeastrum*. All this help has been shared with growers here in Western Australia who joined with the Gladiolus and Dahlia Society in June, 1979.

We imported twice from Holland to further our stock. Then we flew to the USA in 1985 to attend the APLS symposium held in New Orleans. Our intention had been to buy hybrids of our liking. Members of the Board of Directors (of APLS) kept asking us what winter was like in Palmyra. Our garden collects the warmth of sunny days, no frosts, and rainfall from April to November from spasmodic storms.

Our experience with the Quarantine department taught us a permit from Perth was necessary to allow us to bring home bulbs from overseas. We learned that we were to be entrusted with a gene pool of species *Hippeastrum*. A collection of 48 bulbs was gathered, comprised of species, species hybrids, yellows and doubles, all kindly donated by F. Meyer, K. Robertson, J.L. Doran, C.D. Cothran, K. Mann, H. Koopowitz and Mrs. Hilda Latapie of New Orleans (with the beautiful white double cultivar 'Lynn Latapie'.) These bulbs were scaled and cleaned of all soil, packed and air-freighted to Australia. Three days after dispatch they were potted for the required three months. Seven failed in quarantine. However, we were given a surprise when we received notification on February 26, 1986, to collect our last bulb after its ten month stay. *H. papilio* was, apparently, damaged in shipment. The parent bulb died, but before doing so produced eleven offsets around the basal plate. Wow!

In 1988 we once more flew to California to visit friends and flower shows. This time we were to add 20 species *Hippeastrum*, 1 double and 4 yellow hybrids. However, our departure from the USA was rather eventful. As the bag containing bulbs in our hand luggage went through the x-ray, the

airport officer couldn't distinguish what they were. To add to the excitement they could see the outline of my nail clippers in the toilet bag. The officer became confused when we told him they were bulbs. Aussie talk sounded like "bombs", plus the nail clippers... What else could he do? Panic! So ended our farewell from the USA. It was a warm homecoming in Australia to be greeted by Customs officers who were waiting for our flight to collect the "bombs".

In 1989 Les went to the APLS Symposium at Irvine, California, which I hear was an outstanding success. She returned with a further 12 species *Hippeastrum*, 2 yellow hybrids and several other Amaryllids from the Symposium bulb sale and J.L. Doran.

The species are maintained pure and properly identified so that seed can be shared around the world. It hasn't been easy; I have to learn the culture of these beauties. In the shade house I keep a chart with the water requirements over a 12 month period. At the present I have a germplasm of 51 species made up from the imports and seed from United States growers. The yellow breeding programme hasn't progressed. My basic stock is the same as that of C.D. Cothran, who has had outstanding success. Mr. Cothran has been most helpful in supplying all yellow breeding material requested of him. My results are only repeats of his flowers. Still exciting, all the same, to be able to say, "I have bred a yellow." I am awaiting results of seedlings in the future seasons of Cothran stock crossed with Doran yellows.

Doubles are becoming very popular. My first flower was on October 12, 1984, from C.D. Cothran's seed received August 24, 1982. Of the 15 seeds of 'Susan' x 'Double Beauty' 7 grew. The first flower to open has been called 'Mildred Cothran'. It is apricot pink, has 3 rows of petals and produces 4 florets.

My collection of doubles has grown, including 5 imports from the USA and 5 shared from other growers. Don Guthrie has the late Professor Ten Seldam's collection from seed Mr. Seldam brought back from the USA in August, 1982, prior to his death in October of that year. These seed have produced 13 fully doubles of varying colours; one outstanding flower is yellow-cream. The 1989 breeding season taught us that inter-crossing semi-doubles doesn't work -- they all aborted. We have to go back to the basics: pollen from the anthers along the petals of a double onto a good shaped flower with strong tepaloids. This was proved by Mrs. Norma Hay, who produced a large 9 inch bloom of 28 petals using this method. This bloom doesn't produce any pollen at all.

Exciting times are ahead for the culture of *Hippeastrum* in this state, be it species, species hybrids, Dutch hybrids, yellows or doubles. My thanks to Les's pen-friends for their valued help.

WORSLEYA RAYNERI (HIPPEASTRUM PROCERA), "EMPRESS OF BRAZIL"

DONALD VICTOR RIX
PINE HEIGHTS HIPPEASTRUMS
PEPPER STREET, EVERTON HILLS
QUEENSLAND 4053 AUSTRALIA

The growing conditions of *Worsleya rayneri* in its native habitat is unique for it grows in large clusters in steep granite cliffs some 1000 meters above sea level, fully exposed to wind and sunshine. So, you can see that for it to do well, you must "grow it hard". There is practically no soil in the rock crevices but only decaying grass and leaves in which the roots get firmly anchored. At night and early morning dew and moisture seeps into the cracks drenching the roots and fibrous contents. This moisture evaporates in the morning sun.

Sickle-shaped leaves arch over the rock face from the neck of the bulb. These leaves, protected by a silvery bloom from the burning hot sunshine, remain green throughout the year as the bulb does not have a dormant period. Flowering is during the Brazilian winter and in Australia will flower during autumn. The flower head emerges quickly from the long neck of the bulb and opening to present a picture of six to eight pale blue trumpets edged with deeper blue; stamens and style are white with cream pollen, stigma very small with segments that hardly spread. A mature bulb will be four feet tall with foliage arching down to touch the ground; bulb diameter will reach 8 inches.

Follow the natural conditions of this bulb for its cultivation in Australia, do not attempt to grow it in the ground but plant it in a container; 24 inch diameter plastic pots will do. Use a very fibrous mix which contains a fiber that will not rot down readily, e.g.: tree fern, todea, or coconut husks, with alternate layers of rock chips one to two inches in diameter. The bulbs should be watered every two days with the water draining out immediately. Give the plant all the sunlight possible and give the bulb some fertilizer once every six weeks, but do not overdo this. Repot every two years.

(Ed. note: plants are not available from Mr.Rix; seed is rarely available.)

Figure 1 (left). *Worsleya rayneri* in cultivation at the U.C.I. Arboretum, University of California at Irvine. Photo by H. Koopowitz.

PLANTS SOUGHT: AN OPEN LETTER

CARYN ECKER FEATHER
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I lost many of my *Amaryllis* and *Hippeastrum* spp. plants as a consequence of a serious car accident I suffered as a passenger, the long hospital stay required to recover from the accident. Contributing to the loss were subsequent difficulties including serious back and spine problems, and the severe frosts that beset California early in 1991.

I would appreciate so much any spare bulbs of such species and subspecies as *H. pardina, H. ambigua, H. neopardina, H. calyptrata, H. fosteri, H. tucomana, H. braziliana,* and many that I introduced from my collecting trip in 1983 in South America, including *H. bakosovii*. <u>All</u> subspecies or primary hybrids of the listed genera and species are welcomed. I also lost many *Alstroemeria* and South African bulbs. I am now able to get around again to care for them and any contributions would be greatly appreciated.

With hope and appreciation,

Caryn.

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WORSLEYA RAYNERI (HOOKER) TRAUB & MOLDENKE (HIPPEASTRUM PROCERA): ADDITIONAL READING

ELISABETH LASSANYI

Several notes and articles on *Worsleya* have appeared in **Plant Life** and **Herbertia** through the years, including the following.

Traub, Hamilton P. 1943. *Worsleya*, genus nov., Amaryllidaceae. **Plant Life** v. 10, pp. 84-90. A description of the genus and species, pictures of capsules, seeds and a small planting, as well as a discussion and chart of the characteristics which distinguish the genus *Worsleya* from the genus *Hippeastrum* (*Amaryllis* in the text), comprise a large portion of the article.

Strout, Edith B. & Henry J. Lynch 1951. The Blue Amaryllis — *Worsleya Rayneri*. **Plant Life** v.7, pp. 123-130. Highly enjoyable reading, this article was excerpted from Sir Lynch's correspondence on obtaining and growing the species in Brazil, its seed set and humidity needs. Photographs of the 30m bed of plants and of close-ups display the flattened, arching foliage well.

Hudson, Jr., C.J. 1969. Blue amaryllis flowered in South Carolina. **Plant Life** v.25, pp. 105-106. Lytel, A.B. 1942. The blue amaryllis in California. **Plant Life** v.9, pp. 212-214. Both of these are short notes on *W. rayneri*.

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INSTINCT IN THE DEVELOPMENT OF *HIPPEASTRUM*

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In 1981 I started my collection of *Hippeastrum* with bulbs I bought a home-cultured garden bulb from a woman in Montana. This first *Hippeastrum* had six flowers per stem and had been growing in the ground for ten years. I successfully established these very hardy plants which were to become the nucleus of my extensive present day collection. In the beginning I also bought older Dutch hybrids to build up my foundation stock. This was followed up by the addition of six doubles that I obtained in New Orleans, Louisiana. These doubles were most difficult to obtain because at the time they were very tightly held by the original breeders.

In 1983 I started to cross-breed the initial cultivars in order to build up foundation stock in larger numbers. During this time I also ordered bulbs from different sources with disappointing results. The colors were not as represented and flower or stem numbers were not up to the billed amount. I also began buying seeds from all sources that I could. By closely watching how seedlings grew and by keeping good records, I started to select out good breeding lines. Also, I was starting to get good results from cross-breeding of the different Dutch types. Following my instincts with the different lines of breeding, I saw that tangible results were beginning to appear.

Seeds were planted into trays for germination on top of a heated bench 3 feet x 80 feet. Temperature was kept at a constant 70°F where near 100% germination occurred. Some of my initial screening for clones began as early as the seedling stage. I would watch for the most vigorous individuals, which I would pot up into 1 gallon containers (3 per container) and move to the greenhouse. The balance were then planted in an open field. The seedlings that went through the initial screening for vigor were kept in the greenhouse for four years and were selected out for vigor, height, number of flowers per stem, and number of stems per plant.

The bulbs that were planted out in the open field endured two years' exposure to the elements. Sometimes temperatures were as low as 23°F at night and as high as the 100°F range in summer. The most vigorous of these were then lifted and replanted in the greenhouse for further scrutinization. This process of outdoor selection is continuing in its seventh year.

All of my breeding lines fall in five different but sometimes overlapping criteria including plant height, vigor, stem height, flower and stem count and doubleness. 21,000 seedlings currently occupy the benches in an impressive greenhouse facility. 6,000 square feet of this controlled area are fitted with clean cement flooring, a fertilizer injector, and three 50 gallon stainless steel

tubs containing fungicides, fertilizers and minerals.

Breeding still continues with the goal of obtaining field and greenhouse strains of the different lines that will flower from seed in 18 months and produce a saleable bulb in the shortest time. I currently have a strain that home gardeners can grow and commercial growers can sell with four flowers, not just two, 20% of this strain having two scapes of four flowers on each stem. Leaves of this strain are present at flowering time.

With one of the largest gene pools of doubles, I am continuing to produce exciting results. I am producing about 3,000 seedlings per year and still going. Tables 1 and 2 show some of my major crosses from 1984 and 1986. When I cross the species with the doubles I get about a 1:1 ratio of singles to doubles. All of these exhibit extreme vigor. We have experience working with hybrid populations and clonal stock, growing over 500,000 in the greenhouse and 3,000,000 in the field. It has been a lot of hard work, but that is how I picked my best lines.

Some of the most integral strains to my breeding program are to follow. They Keys strain was offered to me in 1985 by Wesley N. Keys' family who was managing his estate. Mr. Keys had created some of the finest hybrids with strong reds, pinks and other assorted colors. There were about 400 bulbs and 200 bulblets in this collection. It is with the Keeys strains crossed with my seedling that I obtained my best double red. To my surprise, Mr. Keys was not aware of the presence of genes for doubleness in his hybrid strains.

Seedlings of the Lorez strain were planted in open fields where they grew for two years. I only picked out the most vigorous of these for a final evaluation. The ones that passed through this initial screening were then treated with fungicides and placed in the green house. This strain exhibited extreme vigor once placed in the controlled environment of the greenhouse. We then crossed a Dutch strain with the Lorez line to achieve a 21°F temperature tolerance.

I have some of the best double lines in my collection. White doubles were derived from a *Hippeastrum* I found naturalized in the Mecca Mountains of Mexico, between Guadalajara and Puerto Vallarta, Jalisco. The population was not native to this area but either an older hybrid of unknown origin or an introduced species. This exotic Mexican collection, when crossed with other double cultivars such as 'John Deme' and 'Judy Weston' and with the Keys strain, gave rise to a new double strain. I will now in 1992 have a white double with 1/8 inch red ribboned edges. My doubles are four flowered stems with 2 scapes per bulb.

My belief gained from over 25 years experience working with soils and plants is that instinct is very good to follow. This type of selecting takes a little longer than other methods, but the results are very rewarding in the long run.

Table 1. *Hippeastrum* Crosses and Species - 1984

Number of Crosses	Parental Stock
400	Hybrid *Hippeastrum* x Keys Hybrid
36	Princess Murat x Orion
26	Dutch Bell x Maria Goretti
33	Self Yellow x Pink Stripes
11	Princess Murat x Johnsonii
36	Dutch Bell x Fire Dance
6	Johnsonii x Princess Murat
8	Dutch Bell x orange Johnsonii
11	Mathis' Strawberry x Dutch Bell
26	Striped Beauty x Cothran's Yellow Pink Stripe
35	OS x MR Self
12	Striped Beauty x Clear Yellow = 1
20	Johnsonii x *H. starkii* x *EAE* x *H. parodii*
103	Firefly x 1107-2 Yellow
34	Eleanor x Self MR
28	(437-1 x Stripe Beauty) x 716-1
82	Firefly x Judy Deme

Table 2 *Hippeastrum* Species Crosses - 1986

No. of Crosses	Parental Stock
114	Fire Fly x 1107-2 Yellow and Pink
16	(*H. evansiae* x *H. leopoldii*) x Manning #2
65	Lucky Strike x Johnsonii
27	*H. flamigera* x *H. cybister*
13	Orange Star x Great Pumpkin 8"-10" Flowers
16	*H. parkeri* Mutatron x *H. arboricolum*
4	591-27 Mann Green x 373
200	Princess Murat x (*H. starkii* x *EAE* x *H. parodii*)
16	(PH28-A Parkerii = Mutatron) x (Bella x Queniannana "Self")
30	*H. neopardinum* x *H. yungacensis*
26	*H. evansiae*-1 x H-20 *H. neoleopoldii*
45	*H. traubii* x SI- *H. papilio* x *EAE*

ERRATA

HERBERTIA vol. 45 (1&2), 1989

Page iii, In This Issue...

Not all the papers presented at the International Symposium on Bulbous and Cormous plants in Irvine, California in 1989 were published in volume 45. Remaining papers have appeared in 1990 and 1991 issues or will be published in upcoming issues, notably volume 48, the forthcoming issue on flora of southern Africa.

Miyake, Isamu. Breeding Spotless *Alstromeria* in Japan. Figures on page 41 should read as follows: Figure 3. The spotless yellow Miyake strain of *Alstroemeria*. Figure 4. The spotless red Miyake strain of *Alstroemeria*.

Tsuchiya, T. & A. Hang. Cytogenetics in the Genus *Alstroemeria*. On page 167 two figures, figures 1b and 2b of somatic chromosomes, were omitted. Also, the figure on the left is figure 2a, *A. aurantiaca*, while the figure on the right is figure 1a, *A. psittacina*. Also, Dr. A. Hang may be contacted at USDA-ARS, National Small Grains Germplasm Program, P.O. Box 307, Aberdeen, ID 83210, United States of America.

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Rudall, P. & A. Kenton. Collecting Iridaceae in Central and South America. Page 45, paragraph 2, lines 16-17 should read *Rigidella orthantha* (Figure 18), not *Rigidella ortlanla*. Page 45, paragraph 3, line 3: *Hesperoxiplion* should be *Hesperoxiphion*. Page 48, line 8: *Euletlerine* should be *Euletherine*.

Volume 2 Table of Contents, pg. 67. The author listing for "Six New Species of *Zephyranthes*" should read as follows: T.M. Howard & S. Ogden.

Meyer, F., R.J. Griesbach & H. Koopowitz. Inter- and Intraspecific Hybridization in the Genus *Ornithogalum*. Virtually none of the figures on pages 136-137 matches the captions as printed. For example, the caption for figure 14 (#91, a dwarf, pot type plant) goes with figure 17, the rightmost figure of the center row on pg. 137; the second figure from the top on the right side of pg. 136 is #289, tall, saturated color types, not #96. More detailed errata for these pages may be published in vol. 48.

HIPPEASTRUM HYBRIDS

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Hippeastrum is a lovely bulbous ornamental and has been universally cherished by amateur gardeners and horticulturists. Keeping in view the importance of this beautiful flower, an improvement program for hotter climatization on genetic lines was initiated at NBRI, Lucknow; with the following objectives:

Basic: experimental analysis of the causes of variation and evolution
Applied: experimental synthesis of new and novel hybrids with better putative parents.

Cross breeding attempts have resulted in raising many desirable varieties with attractive and new color combinations. Selection has been made owing to their hardiness in climatic conditions of our plains. Two new *Hippeastrum* hybrids are reported here.

'APURB'

This hybrid was raised between a cross involving cv. 'Minerva' (4*x*) and cv. 'Lady-Lancaster' (4*x*). It produces flowers during April to May. Flowers are medium sized, (10.0cm across), bell shaped and belladonna type. It produces 2 scapes (45-50cm tall) bearing 4 beautiful flowers in each. Flowers are very colourful having 16-20 crimson (22/2) colored veins (streaks) radiating parallel to the lengthwise over the perianth. There is also a marked greenish white throat at the base. The tepal-tube is 3.0cm. Paraperigone present but inconspicuous, eye present.

This is a seed setting variety and produces seeds freely. Hybrid 'Apurb' is a distinct variety and the name has been given after its colour pattern, which appeals well to everyone.

'CHITWAN'

'Chitwan', a diploid cultivar, was raised from a cross between cv. 'Saturn' and cv. 'Deepali'. The hybrid produces two to three 12.0cm across, wide open, less marked, *H. leopoldii*-type flowers during March-April. The flowers are bicoloured, being white and flushed with magenta (22/1) colour on both sides of the perigone. Stamens are shorter than the perigone and style and remain inserted within the perigone. The tepal tube is 2.5cm wide; paraperigone is present and eye absent.

'Chitwan' is female sterile but crosses as a pollen parent freely.

OBSERVATION OF AN *HIPPEASTRUM* BREEDING PROGRAM

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My hybridizing of *Hippeastrum* began in 1973. In the years since, I have developed several new cultivars which exhibit characteristics previously not seen in hybrids of this genus. Among these cultivars is a strain of multi-flowered types (6 or more per scape) with either large or small flowers. Large flowered *Hippeastrum* hybrids currently available commercially usually have three or four flowers per scape, while the smaller flowering "gracilis"* types can produce up to five or six flowers per scape. From this initial germplasm I started my breeding program to increase the scape's floret count. Other cultivars I've developed display extensive doubling, often accompanied by a high floret count.

DEVELOPMENT OF SMALL, MULTI-FLOWERED TYPES FOR CUT FLOWER USE

This program started in 1975 with the selection of progeny from the cultivar 'Firefly' from Ludwig company of Holland. Among this population I found a cultivar that produces seven flowers per stalk, but its stem was somewhat short for cut flower use. I crossed this cultivar with the longest stemmed cultivars selected from a seedling population of the "gracilis" strain. Fortunately, this combination was productive in yielding stems of 70-80cm, with many of the progeny having 6-7 flowers. From this population I self-crossed the best cultivars. Two years and over 2000 seedlings later I obtained two cultivars with ten flowers per scape. A photograph of one of these appears in this article.

DEVELOPMENT OF LARGE MULTI-FLOWERED TYPES

I self-crossed a six flowered, pure white seedling from the Van Tubergen Company of Holland to produce a new, selfed population (F_1). About half of the progeny had five or six flowers per stem. From that point I crossbred the best of the generation to further select from the next generation (F_2). Two years later several individuals stood conspicuously above the rest of the 800 progeny produced. These cultivars possessed 120cm tall stems with six delicate flowers apiece and with a pleasing arrangement of mass about the stem. Presently I have selected eight cultivars for commercialization and propagation; they are in shades of pure white, red and orange.

DEVELOPMENT OF DOUBLE CULTIVARS

In 1979 I read an article in Plant Life by Mr. John W. Deme of North Carolina concerning breeding of double *Hippeastrum* and through his kindness I received some pollen (in gelatin capsules and packed in a desicating agent)

↑ A selected, large double; white with red stripes.

↑ A red, double, multiflowered variety.

↑ A 10-flowered "gracilis" type with a white star pattern in the center.

↑ Piccoteed double *Hippeastrum*.

↑ Multiflowered (≈ 9-10 florets), pure white, green throated double.

↑ A predominantly red, 10-flowered "gracilis" type.

↑ A red double with white accents and undulating segments.

↑ A creamy white "gracilis" type double.

by air shipment. I immediately used this pollen on my *Hippeastrum* cultivars and achieved an excellent success rate. It was necessary to apply pollen two or three times to obtain successful crosses, as one application of pollen resulted in only 10% seed set. From 1987 on, splendid double cultivars began to bloom. When double pollen was applied to the "gracilis" strain, small-flowered doubles resulted. When applied to large-flowered types, the double pollen gave large doubles with eight flowers per stem.

I am now throwing my energy into breeding large, green-flowering and autumn-flowering *Hippeastrum* types and will report on the results when the opportunity arises.

*Ed. note: It should be noted that the name "gracilis" is derived from the original name given by the type's hybridizer, Mr. H. Boegschoten. He named this strain the "graceful hybrids", the strain eventually being purchased by G.C. van Meeuwen & Sons who introduced and commercialized this strain under the name 'Gracilis'. See George Alders' article on pages 109-111 of Plant Life volume 6, 1950.

Cultivars of *Hippeastrum*: Their Evolution From the Past and Their Development For the Future

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Hippeastrum were cultivated and hybridized as far back as 1790, principally in Holland and England. During the 1860's, especially, there was much interest in hybridizing and showing new cultivars. However, it was not until the 1920's that these majestic plants became generally available to the public. Great strides were made in introducing specimens which were more dependable to flower regularly after the Second World War. Many of today's popular cultivars grown in the Northern Hemisphere date from the 1950's and include such Dutch favourites as Red Lion (1958) and Apple Blossom (1954), both of which are still today's leading Dutch cultivars.

HADECO started hybridizing *Hippeastrum* during this period of the 1950's. From the outset it was our intention and aim to produce clones which would flower prolifically and easily and to this end HADECO has consistently marketed its own exclusive range of cultivars. Since HADECO *Hippeastrum* are produced in the southern hemisphere in seasons opposed to those of the northern hemisphere, they flower naturally in the northern hemisphere fall and winter periods. From the start the emphasis in the hybridizing programme was based on the following criteria:

A. 1. To produce cultivars which do not fail.
2. To produce cultivars which show foliage together with blooms.
3. To produce compact plants.
4. To produce cultivars which have good bulbs with strong root systems.

B. 1. To produce even larger blooms,
2. To produce even more blooms per stem,
3. To produce even more stems per bulb,
4. To produce even smaller bulbs doing all of the above.

C. 1. To produce better shaped blooms,
2. To produce better colors of blooms,
3. To produce better lasting blooms.

Many trouble free, high performing cultivars have been bred by HADECO and they include such well known names as 'Zanzibar' (1963), 'Safari' (1961), and the now defunct 'Tangerine' (1973) which flowered with 2 floral scapes of 4 or 5 florets each from bulbs no larger than tennis balls. These cultivars have evolved into today's larger flowered and shorter stemmed beauties such as 'Sun Dance' (1980). 'Sun Dance' has superior color and floret shape to

'Zanzibar' and a very high consistency in producing its 2 spikes in close order. 'Tangerine' has been superseded by 'Miracle', which combines the small bulb size of the former with larger, darker colored blooms.

Great strides have been made in producing easy to grow and prolific flowering cultivars in colors which were previously deemed difficult such as today's superior pink 'Summer Time' from HADECO. Or the two pure white cultivars 'Wedding Dance' and 'Intokazi'. The name 'Intokazi' is Zulu for "maiden" or "virgin".

All of today's HADECO cultivars have a tendency to show off their foliage together with the floral stalks and, thus, give the plants a fuller aspect. Over the past 20 odd years the emphasis has been on breeding far more blooms per spike and more spikes per bulb and all this from ever smaller sized bulbs. The bulbs of present day HADECO cultivars rarely grow larger than 30cm circumference (3.75 inches diameter) and many cultivars will not produce bulbs larger than 3.5 inches.

The cultivar which is today's favourite in red, 'Sun Dance', may soon be superseded by an even more spectacular clone. Just as 'Sun Dance' is a great improvement on 'Zanzibar' in color, flower size and shape, more compact stems, stronger bulbs with massive roots; so its successor must be superior in all respects. Planned new introductions for the coming years will include such stunning huge flowering masterpieces as 'Merry Christmas'. Further down the line, cultivars are being developed with even more flowers and spikes.

In addition to seeking to simply improve existing traits, the emphasis of the hybridizing scene at HADECO has shifted to the development of fully double-flowered clones on the one hand and miniatures on the other hand. HADECO is well advanced in its work on the doubles and selected clones in all the normal color variations are being vegetatively increased for production. These should be generally available by 1996. Looking somewhat further into the future are the miniatures. HADECO perceives a market for *Hippeastrum* which produce 2, 3 or 4 scapes, each with between 4 and 7 dainty florets from a bulb no larger than a golf ball or chicken egg. Such a product will not only find appeal as a flowering pot plant with one or more bulbs per pot but also as a garden bulb for areas with relatively mild climates. Although this area of research shows exciting promise there are many obstacles on the road to success. The main hurdle to cross is that of virus susceptibility which is prevalent in the miniature lines. We are however fairly confident that these problems may be overcome in time.

▲ Above: Possible new introductions & existing cultivars being evaluated in the HADECO test house.

◂ Left: Double flowered clones.

Lower left: Cultivars in bloom in the HADECO fields.

Below right: 'Merry Christmas' & Floris Barnhoorn, HADECO Joint Managing Director. ▾

▲ Figure 5 (above). New multi-flowered clone from small bulbs.

▲ Figure 6. Double flowered clone, above right.

▼ Figure 7 (below). New miniature cultivars under development. Note small bulb size.

NOTES ON *RHODOPHIALA RHODOLIRION* (AMARYLLIDACEAE) FROM THE ANDES OF MENDOZA, ARGENTINA

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SUMMARY

A short survey of the taxonomic history of *Rhodophiala rhodolirion* (Amaryllidaceae) is given. Some observations on the habitat, ecology and phenology of populations studied in the Andes of Mendoza, Argentina, are also reported.

INTRODUCTION

The species discussed here was originally described by R. Philippi (1857) as *Rhodolirion andinum*. The type specimen was collected by Vicente Bustillos in the Andes of San Fernando, (Province of Colchagua, Chile). Baker (1878) transferred the species to the genus *Hippeastrum* and gave it the new name *Hippeastrum rhodolirion* because of the homonym *Hippeastrum andinum* (Philippi) Baker (1878), a different species based on *Rhodophiala andina* Philippi (1873), a plant with 4-6-flowered inflorescence. The use of the same epithet in related genera with similar generic names (i.e., *Rhodolirion* and *Rhodophiala*) and the fluctuations in their taxonomic recognition by subsequent authors necessarily caused some confusion. Philippi (1896) himself contributed to it by repeating the description of *Rhodophiala andina* ("scape 4-6-flowered") under the heading "*Hippeastrum* (*Rhodolirion*)? *andinum* Ph." which, according to the original description of *Rhodolirion andinum* Philippi (1857) ("pedunculo brevi" and "pedunculus 8-9, ovarium 4½ lin.") evidently had a one-flowered inflorescence. The nomenclatural and taxonomic history of the two taxa is therefore shown synoptically in Tables 1 and 2.

The plant discussed in this paper has undergone several name changes. From *Hippeastrum* it was transferred to *Amaryllis* by Traub and Uphof (1938) who failed to take up the earlier epithet "andinum". Finally, Traub (1953) placed it in *Rhodophiala*, as a result of his restoration of the genus (Traub, 1952). Here, again, the epithet of the basionym, "andinum", was unavailable because of the homonym *Rhodophiala andina* Philippi (1873: 543).

It must be stressed here that the basionym of *Rhodophiala rhodolirion* (Baker) Traub (1953) is *Rhodolirion andinum* Philippi, not *Rhodophiala andina* Philippi. The latter taxon is a distinct species from the Andes of Santiago with an even more complex history. Baker (1878) made the combination *Hippeastrum andinum* and

listed *Rhodophiala? andina* as synonym. Ten years later he included *Rhodophiala andina* in the bright-red-flowered *Hippeastrum herbertianum* (Lindley) Baker (Baker, 1888), a plant better known as *Phycella herbertiana* (Lindley, 1830; Traub, 1953) but also placed in other genera in recent years, i.e., in *Famatina* by Ravenna (1972), and in *Rhodophiala* by Hunziker (1985). After R. Philippi (1873), Ravenna (1972, pg. 62) is the only recent author who maintains *Rhodophiala andina* as a distinct species without giving any details. While we cannot contribute anything to solve this question, a portrait of *Phycella herbertiana*, as observed in the mountains between Mendoza and Uspallata, is in preparation for a later paper.

Returning to the plant mentioned in the title, some additional data can be taken from literature. *Rhodophiala rhodolirion* was described as having a one-flowered inflorescence, purple, openly funnel-shaped flowers, stamens half as long as the limb, style overtopping the stamens, and capitate stigma. The distribution of *Rhodophiala rhodolirion* is restricted to the Andean and sub-Andean zone of Argentina (Province of Mendoza, Department of Malargüe) and the adjacent area of Chile (Province of Colchagua). Hoffmann (1979) and Ravenna (1969) also mention it for the Chilean Provinces of Aconcagua and Santiago.
In Chile, *Rhodophiala rhodolirion* is locally known under the common name "Añañuca de Cordillera" (Hoffmann 1979). It is a very showy plant which deserves protection in its natural habitat.

MATERIAL AND METHODS

Field observations were made during January 1988 and February 1989 at two sites with remarkably rich populations of the species, both in the Rio Salado Valley in the Department of Malargue, Mendoza, Argentina. At both places living material and seeds were collected as well as herbarium specimens and material in FAA. The herbarium material (Leuenberger et Arroyo 3803, 3804, 3891 and 3904) was deposited at the Centro de Estudios Farmacológicos y Principios Naturales, Buenos Aires (BACP) and at the Botanischer Garten und Botanisches Museum Berlin-Dahlem (B). In the field, apart from the morphological observations and photographic documentation, air and soil temperatures were measured with an electronic thermometer.

HABITAT

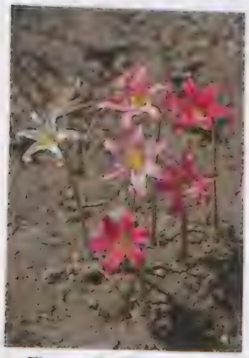
According to our observations in Argentina, *R. rhodolirion* is found at an altitude of 1600 to 2200m in the upper part of the Río Salado Valley and in the Valle Hermoso at 2700m. The first locality studied is at 13km from Los Molles towards Las Leñas just before the road crosses the Río Salado at Arroyo Deshecho, at 2000m altitude (Figures 1 and 2). The second is just south of Las Leñas on the slopes on and below giant moraines at 2150m (Figure 4). The species is very common on sandy or gravelly soil in valleys with various geological strata such as granite, schists or, exceptionally, calcareous components.

At Arroyo Deshecho *R. rhodolirion* was found associated with shrubs and subshrubs such as *Verbena* sp., *Chuquiraga oppositifolia*, *Argylia bustillosii*, *Astragalus cruckshankii*, *Berberis empetrifolia*, *Mulinum spinosum*, *Calceolaria germainii*, and

▲ Figure 1. Habitat of *Rhodophiala rhodolirion*, Arroyo Deshecho, 2000m, Río Salado Valley, Mendoza, Argentina.

▲ Figure 2. Dense stand of *R. rhodolirion* (locality as in Figure 1).

▼ Figure 3. Arroyo Deshecho's *R. rhodolirion* population showing variation of flower color.



▼ Figure 4. Habitat of *R. rhodolirion* at Las Leñas, 2150m, Mendoza, Argentina.

▼ Figure 5. One-flowered inflorescence with two spathe leaves, showing curved style & filaments

▼ Figure 7. Flower with large, straight anthers prior to dehiscence.

▼ Figure 8. Flower showing curved anthers after dehiscence.

▼ Figure 9. Flower with bees inside.

◂ Figure 10. Immature capsule with persistent perianth and bracts.

▴ Figure 11. Mature capsules showing three stages of dehiscence and seed dispersal.

▴ Figure 6. Two-flowered inflorescence with the two free spathe-leaves, one flower-bud and one flower.

▴ Figure 12. Variability of shape and size of capsules.

grasses and herbs like *Hordeum comosum* and *Calycera viridiflora*. In Las Leñas the vegetation is more uniform and dominated by a grass (*Festuca kurtziana*) (Figure 4) with few herbaceous plants such as *Viola* sp., *Calandrinia* sp., *Oxalis erythrorhiza*, and *Marsippospermum* sp.

ECOLOGICAL DATA

According to local informations snow can fall in the months of June to September, exceptionally in October. The snow cover varies from very little to about 80 to 200cm in the valley floor, but due to the strong wind the snow cover depends much on the exposure of the slope. Daily temperature minima in winter range from -3°C to -26°C.

Some observations on air and soil temperature in summer could be made in February 1989 on several sunny and moderately windy days from shortly after dawn (8 a.m.) to shortly after sunset (8:45 p.m.). The few measurements (see Tables 3 and 4) can only give a general idea of the temperature regime on the few selected days but, neverthele.., show the strong fluctuation of temperature of the air and uppermost soil layers. They also show that the soil layer

containing the bulb at ca. 15cm depth maintains a relatively high temperature of 17-25°C.

FLOWERING

The flowering period of this species is from December through February or March. During our visit practically no leaves were seen on the plants. Apparently, old leaves are rarely still alive at this time. At the end of the flowering season new ones can be found. Also, leaves are soon grazed by local domestic animals, particularly by goats.

In January, 1988 a great number of bulbs in both localities had flowers. Various stages of buds and flowers were found within the same population. The inflorescences are normally one-flowered, rarely 2-flowered (Figures 5 and 6) and the flower is declined. Bulbs with two simultaneously flowering inflorescences occur but each bulb normally develops one inflorescence after the other (Arroyo 1984). Like all *Rhodophiala* species, *R. rhodolirion* has two free spathe leaves and each flower is often, but not always, subtended by a filiform bract, which is visible only when the spathe leaves are removed (Arroyo 1986). The showy flowers normally open at mid-day and remain open for up to 6 days. Variation of flower color is notable from one plant to another. Even in the same population it ranges from light pink to deep red, with exceptional occurrence of white flowers (Figure 3). Strong purple striation of the tepals is visible in some specimens. At the beginning of anthesis the still indehisced six anthers are straight and of remarkably large size (Figure 7). Soon after they shrivel to about one fifth of their length due to dehydration and become curved (Figure 8). The filaments are of unequal length and like the style they are strongly curved upwards. The style surpasses the anthers in length and the stigma is globose.

INSECTS OBSERVED IN THE FLOWERS

The following bees were found hiding during the afternoon in the flowers of *R. rhodolirion*: *Diadasia* sp. and *Centridines centris* (both of family Anthophoridae), *Megachile* sp. (of fam. Megachilidae), and others from the tribe Eucerini of family Anthophoridae (Figure 9). No observations could be made on the pollination because the bees were only found resting in the flowers but not flying from one to another.

FRUCTIFICATION

The capsules are erect and the color of immature capsules varies from greenish to brownish (Figure 10). The perianth and the bracts remain on the capsule for some time (Figure 12). Mature capsules are brown. Characters such as fruit size and fruit form show such a great variation that they should be considered only with great care for species delimitation. In the fairly frequent two-flowered inflorescences only one ovary was observed to develop into a capsule with seeds.

SEED

After the dehiscence of the capsule the seeds remain attached to the suture until they are dehydrated (Figure 11). The number of seeds per capsule varies from about 25 to 50. They are thick and fleshy inside at the stage of capsule dehiscence but apparently dehydrate when exposed to the sun and are thin at the stage of dispersal, which is evidently by wind. The seeds are black, flat, and smooth. In both populations neither in seeds nor in capsules any insect damage was observed.

ACKNOWLEDGMENTS

We wish to thank Mr. Luciano Moffat (Museo de Ciencias Naturales B. Rivadavia, Buenos Aires) for the identification of the bees.

Table 1. Synopsis of the taxonomic history of *Rhodophiala rhodolirion*.

Author	Year	Accepted Name and Synonyms
Philippi	1857	*Rhodolirion andinum* Philippi
Baker	1878	*Hippeastrum rhodolirion* Baker ≡ *Rhodolirion andinum* Philippi (1857)
Baker	1888	*Hippeastrum rhodolirion* Baker (1878) ≡ *Rhodolirion andinum* Philippi (1857)
Philippi	1896	*Hippeastrum (Rhodolirion)? andinum* Philippi[1] ≡ *Rhodolirion andinum* Philippi (1857) ≡ *Hippeastrum rhodolirion* Baker (1878)
Traub & Uphof	1938	*Amaryllis rhodolirion* (Baker) Traub & Uphof
Traub & Moldenke	1949	*Amaryllis rhodolirion* (Baker) Traub & Uphof (1938) ≡ *Rhodolirion andinum* Philippi (1857) ≡ *Hippeastrum rhodolirion* Baker (1878) ≡ *Hippeastrum (Rhodolirion)? andinum* Philippi (1896)[1]
Traub	1953	*Rhodophiala rhodolirion* (Baker) Traub ≡ *Hippeastrum rhodolirion* Baker (1878)
Ravenna	1971	*Rhodophiala rhodolirion* (Baker) Traub (1953) ≡ *Hippeastrum rhodolirion* Baker (1878) ≡ *Rhodolirion andinum* Philippi (1857) = *Rhodolirion montanum* Philippi (1857)

[1] (excluding Philippi's description, which corresponds to *Rhodophiala andina*)

Table 2. Synopsis of the taxonomic history of *Rhodophiala andina*

Author	Year	Accepted Name and Synonyms
Philippi	1873	*Rhodophiala? andina* Philippi
Baker	1878	*Hippeastrum andinum* (Philippi) Baker ≡ *Rhodophiala? andina* Philippi (1873)
Baker	1888	*Hippeastrum herbertianum* (Lindley) Baker (1878) ≡ *Phycella herbertiana* Lindley (1830) = *Rhodophiala? andina* Philippi (1873) ≡ *Hippeastrum andinum* (Philippi) Baker (1878)
Ravenna	1972	*Rhodophiala andina* Philippi (1873)

Table 3. Temperature measured during February 1989 in Arroyo Deshecho (north exposed slope with 5° inclination, steady wind from the east).

Measurement location	Time: 8-8:20	Time: 12:45	Time: 14:45	Time: 20:45
Air	4.9-6.0°C	23.4°C	25.6-27.5°C	16.0-18.5°C
Soil, 0-1cm	6.9°C	38.6-45.0°C	46.1-64.0°C	23.0°C
Soil, 2-4cm	10.7°C	23.1°C	47.5°C	25.8°C
Soil, 15cm	20.6°C	20.5°C	22.0°C	25.8°C
Bulb	20.4°C	21.0°C	21.8°C	28.2°C

Table 4. Temperature measured during February, 1989 in Las Leñas (N=north, W=west-exposed slope, 5° inclination).

	Time: 11:15, (N)	Time: 12:30, (N)	Time: 19:40 (N)	(W)
Air	19.8°C	22.0°C	21.0°C	21.0°C
Soil, 0-1cm	39.5°C	42.0°C	22.0°C	
Soil, 2-4cm	24.8°C	28.0°C	25.0°C	35.5°C
Soil, 15cm	17.5°C	18.5°C	25.5°C	
Bulb	15.5°C	16.5°C	23.0°C	24.2°C

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BREEDING NEW VARIETIES OF *HIPPEASTRUM* WITH BRAZILIAN NATIVE SPECIES

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INTRODUCTION

The Instituto Agronômico started a breeding program with *Hippeastrum* in 1982 aiming to breed new varieties from the native species. Initially, crosses were made by Luiz A.F. Matthes and Julie H.A. Dutilh between Dutch hybrids and native species and also between each other, involving mainly *H. blossfeldiae, H. striatum, H. stylosum, H. muesserianum, H. puniceum*, *H.* sp. "Atibaya", *H. psittacinum* and *H. reginae* (Tombolato & Castro, 1989.) After eight years we can observe the progeny — the second and some of the third generation of these crosses — blooming at São Roque Experimental Station in São Paulo.

THE COLLECTION

During the last two years several collection trips were made to obtain new types and species of Amaryllidaceae with the purpose of obtaining material for new crosses. Besides the *Hippeastrum* breeding program the Instituto Agronômico also has a breeding program for *Alstroemeria*, including *Bomarea*.

Several localities were visited in the states of São Paulo, Rio de Janeiro and Minas Gerais, in the southeast region of Brazil. In these trips several samples were collected comprising different types of *H. psittacinum, H.* sp. "Atibaya", *H. puniceum, H. calyptratum, H. blossfeldiae, H. reticulatum* and *H. petiolatum*, as well as non-flowering plants of unidentified species. It was observed that great variability exists between native populations and among individuals (Dutilh, 1989), so, when possible, morphologically different types were collected during flowering time in order to ensure genetic variability in our collection.

SELECTION OF F_1 PLANTS

From the total of exactly one thousand F_1 plants present at the São Roque Experimental Station two years ago, only 62 plants remain after selection. These plants are now being propagated, largely *in vitro*, for further observation and trials. Some of the more promising selected hybrids were

sent to the firm Klaas Schoenmaker from the Cooperativa Agrícola Holambra. This firm will conduct final evaluations of these hybrids for possible introduction into intensive commercial production. These hybrids are the following:

IAC 29-B: Dutch hybrid x *H. blossfeldiae*

IAC 46-8, IAC 46-9, IAC 46-15, IAC 46-20, IAC 46-21, IAC 46-25 and IAC 46-26: *H. blossfeldiae* x Dutch hybrid.

IAC 56-D: *H. blossfeldiae* x Dutch hybrid

IAC 60-A and IAC 60-I: Dutch hybrid x *H. striatum* var. *acuminatum*

IAC 74-C: Dutch hybrid x *H. blossfeldiae*.

THE F_2 GENERATION

In 1986 and 1988 the second generation of the crosses was made using plants obtained from the initial crosses that were made in 1982/1983. This generation included crosses of unrelated material, crosses of siblings, self pollinations and open pollination. These 1986 and 1988 cross lines are named respectively as series 86 and series 88. They are in cultivation at the São Roque Experimental Station in very sandy soil and full sun at an alititude of approximately 800m. The soil is very poor in organic mater, an adverse condition, especially since the majority of species occur in wet soils that contain high amounts of organic matter.

Unlike descendants of *H. blossfeldiae*, the offspring of several lines, mainly those involving *H. striatum* and *H. psittacinum*, face local conditions with great difficulty. This behaviour, no doubt, is due to the adaptive characteristics of the parent species. While *H. blossfeldiae* usually occurs in sunny locations near beaches, *H. striatum* and *H. psittacinum* occur in entirely organic substrates in the shade of trees. It must be emphasized that intensive culture of Dutch-type *Hippeastrum* (Amaryllis) hybrids is normally done under full sun in field conditions.

From July to November, 1990, we noticed that series 86 plants bloomed intensively. We selected approximately half of these plants for further growth and observation under field conditions. A smaller group of these was selected for multiplication for more accurate and intense scrutiny. The genealogical list of series 86 plants is contained in Table 1, and that for series 88 plants is in Table 2 on the following page.

Table 1. *Hippeastrum* crosses, 1986, at the Instituto Agronômico	
Number (quantity) of crosses	Parental Stock
2	(Dutch hybrid x *H. blossfeldiae*) x (*H. stylosum* x *H. blossfeldiae*)
2	(Dutch hybrid x *H. blossfeldiae*) x Dutch hybrid
1	(*H. blossfeldiae* x *H. striatum*) x (Dutch hybrid x *H. blossfeldiae*)
1	(*H. blossfeldiae* x *H. striatum*) x Dutch hybrid
3	(*H. blossfeldiae* x Dutch hybrid) x (Dutch hybrid x *H. blossfeldiae*)
1	(Dutch hybrid x *H. striatum*) x (*H. striatum* forma *acuminatum* x *H. striatum*)
1	(*H. blossfeldiae* x Dutch hybrid) x Dutch hybrid
1	(Dutch hybrid x *H. blossfeldiae*) x *H. blossfeldiae*
1	(Dutch hybrid x *H. blossfeldiae*) x (Dutch hybrid x *H. blossfeldiae*)
3	self (Dutch hybrid x *H. blossfeldiae*)
1	self (*H. stylosum* x *H. blossfeldiae*)
2	self (*H. blossfeldiae* x Dutch hybrid)
1	self (*H. blossfeldiae* x *H. psittacinum*)
3	self (Dutch hybrid x Dutch hybrid)
1	self (self Dutch hybrid)

Table 2. *Hippeastrum* crosses, 1988, Instituto Agronômico	
Number of crosses	Parental Stock
1	(*H. puniceum* x *H. reginae*) x (Dutch hybrid x Dutch hybrid)
1	(*H. aff. reginae* x *H.* sp. "Atibaya") x (Dutch hybrid x Dutch hybrid)
1	(*H. puniceum* x *H. psittacinum*) x Dutch hybrid
4	(*H. stylosum* x *H. blossfeldiae*) x Dutch hybrid
1	(*H. stylosum* x *H. psittacinum*) x Dutch hybrid
3	(*H. blossfeldiae* x Dutch hybrid) x Dutch hybrid
1	self (*H. reginae* x *H. puniceum*)
1	(*H. stylosum* x *H. psittacinum*) x Dutch hybrid

Table 2. *Hippeastrum* crosses, 1988, Instituto Agronômico

Number of crosses	Parental Stock
1	(*H. blossfeldiae* x Dutch hybrid) x (Dutch hybrid x Dutch hybrid)
1	(Dutch hybrid x *H. blossfeldiae*) x (*H. stylosum* x *H. psittacinum*)
8	(Dutch hybrid x *H. blossfeldiae*) x Dutch hybrid
1	Dutch hybrid x Dutch hybrid
4	Dutch hybrid x (Dutch hybrid x *H. blossfeldiae*)
2	Dutch hybrid x (*H. stylosum* x *H. blossfeldiae*)
1	(Dutch hybrid x Dutch hybrid) x (*H. blossfeldiae* x Dutch hybrid)
1	(Dutch hybrid x *H. blossfeldiae*) x (*H. blossfeldiae* x Dutch hybrid)
1	(*H. stylosum* x *H. psittacinum*) x Dutch hybrid
5	(Dutch hybrid x Dutch hybrid) x (Dutch hybrid x Dutch hybrid)
1	(*H. stylosum* x *H. blossfeldiae*) x (Dutch hybrid x *H. blossfeldiae*)
1	(Dutch hybrid x *H. striatum*) x (*H. blossfeldiae* x Dutch hybrid)
3	(*H. blossfeldiae* x Dutch hybrid) x (Dutch hybrid x *H. striatum* forma *acuminatum*)
4	(Dutch hybrid x Dutch hybrid) x Dutch hybrid
2	unknown x Dutch hybrid
1	(*H. psittacinum* x *H.* aff. *puniceum*) x (Dutch hybrid x *H. striatum* forma *acuminatum*)
2	self Dutch hybrid x Dutch hybrid
1	(Dutch hybrid x Dutch hybrid) x unknown
3	(*H. psittacinum* x *H. striatum* forma *crocatum*) x Dutch hybrid
2	(Dutch hybrid x Dutch hybrid) x (Dutch hybrid x *H. striatum* forma *acuminatum*)
1	(*H. blossfeldiae* x Dutch hybrid) x unknown
3	(Dutch hybrid x *H. blossfeldiae*) x (*H. stylosum* x *H. blossfeldiae*)
1	(*H. puniceum* x *H.* sp. "Atibaya") x Dutch hybrid
1	(*H. blossfeldiae* x Dutch hybrid) x (*H. psittacinum* x *H. reginae*)
1	unknown open pollinated
1	self (*H. stylosum* x *H. blossfeldiae*)

Table 2. *Hippeastrum* crosses, 1988, Instituto Agronômico	
Number of crosses	Parental Stock
1	self (Dutch hybrid x *H. blossfeldiae*)
4	(Dutch hybrid x *H. blossfeldiae*) open pollinated
2	(*H. blossfeldiae* x Dutch hybrid) open pollinated
10	(Dutch hybrid x Dutch hybrid) open pollinated
2	((Dutch hybrid x *H. blossfeldiae*) x Dutch hybrid) open pollinated
4	self Dutch hybrid
3	(Dutch hybrid x *H. striatum* forma *acuminatum*) open pollinated
4	Dutch hybrid open pollinated
1	(*H.* sp. x *H.* sp. "Atibaya") open pollinated
1	(Dutch hybrid x *H. striatum*) open pollinated
1	(*H. puniceum* x *H. reginae*) open pollinated
1	(*H. puniceum* x *H. psittacinum*) open pollinated

Notice that in series 88 great effort was made to introduce Dutch hybrids into the majority of crosses. This was done despite our main goal of breeding new flower types from native species because our secondary aim was to create easy-to-grow plants. The known difficulties in domesticating native species hardly lend themselves to making hybrids as well adapted to agricultural cultivation as the Dutch types.

Great interest in this breeding program has been demonstrated by foreign visitors. This is due to the increasing interest in ecology throughout Europe where customers prize the native products or features in plants that have not been as intensively processed by humans as the Dutch hybrids have. We agree with this concept to some extent, but the difficulties in cultivation of the native species, as well as their late bloom time, make their widespread use impractical.

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THE *HIPPEASTRUM* (AMARYLLIS) AS A CUT FLOWER

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The *Hippeastrum* makes an excellent plant for cut flower cultivation because *Hippeastrum* flowers have significant ornamental value and good keeping qualities after harvest. The large flowers are excellent for incorporating into large flower arrangements. There are also small-flowered *Hippeastrum* cultivars available in limited but increasing supplies and these varieties are excellent for smaller arrangements.

For the flower grower cultivation is easy to program and can provide first-class flowers in the dark winter months. The cut flowers are a rewarding addition to the range of flowers available for the autumn, winter and spring. *Hippeastrum* are only cultivated under glass in The Netherlands, providing the necessary warm ground temperature for good growth. There has been an increasing tendency recently to leave the bulbs in the ground and not to lift them as the ground, itself, provides the cooling necessary for flowering.

PLANT MATERIAL

For cut flower production, bulbs which generate at least 2 well developed flower stalks are required. When lifting, the size of the flower buds inside the bulb should be at least 20mm when measured from the basal plate. The size of the bulbs used for forcing will often be 28-30cm in circumference but can vary from variety to variety. In general, there are 25 bulbs planted to a square meter. The distance between plants varies according to the method of cultivation, e.g. whether or not the bulbs are lifted, and according to varietal differences. It is particularly important to have an adequate number of established roots on the bulb when it is lifted. Furthermore, the bulbs must be free of root lesion nematodes, acardia and fungal diseases.

PREPARATION OF THE PLANT

For good and even flowering the bulbs have to undergo a cooling period. Tests have shown that the bulbs have to be stored at a temperature of 13°C for at least 8 but preferably 10 weeks. If this advice is not followed and the bulbs are allowed to stand at about 20°C or higher for some time, the flower stalk will not lengthen sufficiently for cut flowers and can result in little or no flowering. Therefore, proper bulb preparation is vital.

Flower growers often have their own preparation facilities or this work is contracted out to cold store and preparation companies. They ensure that the bulbs are not left lying in places with temperatures which are too high after they have been lifted and dried. If necessary, the bulbs can be given

warm water treatment after lifting and drying to control root lesion nematodes and mites.

SOIL AND FEEDING

The soil used for planting must have a particularly good structure. *Hippeastrum* likes light, porous soil that provides optimal conditions for rooting. Often organic material is used in varying amounts, depending on the quality of the soil, and is usually applied as a top layer. Peat is a popular choice as organic material because it does not contain salt. Mushroom compost, for example, is rich in salt and for this reason can only be applied in limited quantities.

Hippeastrum can be counted among the plants which are sensitive to salt. Therefore, the total salt content should be around 1.0 E.C. (electrical conductivity) or less. Considering the high cost of plants, it is advisable to take some soil samples before planting. Usually a light, basic dressing of fertilizer is used as a pre-planting treatment. Initially the soil nutrient concentration should not be too high, as one must allow undisturbed root development, and the soil should be sufficiently moist. Later during cultivation there is ample opportunity for additional fertilization through a fertilizer injection watering system. Also during cultivation an additional soil study will give some insight into the fertilizer concentration. This will determine whether or not proper nutrient levels are being maintained and if fertilizer applications must be altered.

SUPPLYING WATER

Water can be supplied by overhead sprinkler systems. The moisture supply is very important in the initial stages. A badly working sprinkler system results in dry spots which are very difficult to put right later on. A good sprinkler system has 3 jets with a 6.40m watering radius, the jet valves spaced 1.00m apart. An average sprinkler system provides approximately 60mm water per square meter per hour. One of the disadvantages of the sprinkler system is that the plant always gets wet and stays wet for short or long periods, therefore increasing the risk of fungal diseases. For this reason the last years have seen an increasing trend among growers of *Hippeastrum* to use trickle/drip irrigation, which keeps the plant foliage dry. Water is delivered by means of a number of dripping points per square meter and, depending on the soil, there are 2-4 hoses per bed. Newly planted bulbs are first soaked with the sprinkler and later converted to the drip system. Bulbs which have not been lifted have a strongly developed root system and can immediately be put on the drip system at any time.

GREENHOUSE CLIMATE: LIGHT

The greenhouse climate is very critical for optimal growth of the bulb, foliage and flower stalk. It is advisable to grow *Hippeastrum* in modern greenhouses which admit the maximum amount of light possible when light

levels are low during the winter. Modern greenhouses also have the advantage of being adequately ventilated during the summer. Light is especially important to the plant for photosynthesis which greatly contributes to the growth of foliage, bulb roots and flower buds. For flowering there is only a limited need for light. In low light winter conditions, *Hippeastrum* grown for cut flowers will develop well. However, limited amounts of light will affect the structure and firmness of the plant. When light levels are too low the leaves will easily become long and soft, and the flower stalks will be less rigid. Therefore, correct climate control is important during growth.

Sometimes in summer too much light shines into the greenhouse and many growers are inclined to whitewash the greenhouse cover. The light is seldom too bright here because the weather is often very changeable. However, in other countries a whitewash screen will be more of a necessity because of the continually good (sunny) weather. There are an increasing number of greenhouses equipped with mobile screens made of shade cloth which make it possible to completely close the screen when the sun's rays are very intense. Direct sunshine on the plants is then restricted and the plant temperature does not increase too much.

TEMPERATURE

A distinction should be made here between air temperature and soil temperature.

A. AIR TEMPERATURE

The air temperature can be quite high from the moment of planting right up to harvesting. The air temperature is kept between 18-20°C for optimum growth of the flower stalks. After the flowers have been harvested, the temperature will be decreased and is often kept at 14-16°C so that the development and firmness of the leaf can be monitored. Higher temperatures will result in the plant becoming etiolated.

B. SOIL TEMPERATURE

This is extremely important because *Hippeastrum* requires a sufficiently warm soil temperature. The bulb's point of growth is in the ground which means the temperature of soil directly affects the plant. Roots, leaves and flower stalks have optimal growth when ground temperature is approx-imately 22°C. In the Netherlands soil heating is necessary in order to achieve and maintain this temperature at a constant level. Eight heating hoses are installed approximately 45cm under the soil for every 6.40m of width. This soil heating circuit is operated separately from the heating above ground.

HUMIDITY

Initially after planting the humidity is kept high. At this early stage there is very little foliage growth while the whole root, leaf and stalk development process is just getting underway. The newly planted bulbs are

often covered with perforated plastic film or sometimes with a porous plastic cloth (**Agryl**). After several weeks the foliage and stalk have reached an active stage of development and at this point the plastic or cloth is removed. If it were not removed there would be a decrease in the quality of the flower stalks. It is recommended to remove the film or cloth on a dark day, otherwise the abrupt change in light levels would be too great for the plant.

The prevailing humidity strongly depends on the conditions outdoors and the way in which the greenhouse climate is controlled. Sometimes it will be necessary to heat and ventilate simultaneously owing to excessively high humidity. Long periods of humidity encourage fungal diseases such as *Stagonospora*. It is also dangerous to reduce the constant temperature from between 18-20°C. Lower temperatures mean that the air becomes saturated with moisture more quickly and the plant then becomes damp from condensation. This is particularly critical during of the harvesting period. During the active growth period humidity can become too low as a result of intense light transmission and leaf scorch can then occur. Try to deal with this by ventilating in time, watering and restricting light.

SUPPLEMENTAL CO_2

For photosynthesis not only an abundance of light but also a lot of CO_2 is necessary. When there is a lot of light and insufficient ventilation in modern, closed greenhouses a lack of this important building substance can arise. For optimum growth dosing with extra CO_2 is advisable. Research results show a considerable increase in growth with a CO_2 level of 1000ppm. This is approximately 3 times as much as the normal amount found in the air. CO_2 is only absorbed by the plant when there is light, therefore dosing at night is pointless.

FORCING PERIOD

After planting it takes 5-8 weeks before flowering begins, largely depending on the variety. The flowering period lasts approximately 4 weeks. The forcing period can be reduced by about one week by applying a heat treatment to the unplanted bulbs at 23°C for a period of 7-14 days after storage at 13°C. This method is not suitable for bulbs which have been stored for longer periods because these bulbs will already flower sooner than otherwise. Both storage at 13°C and heat treatment at 23°C can be given in the storage room. To attain the necessary forcing period, a greenhouse temperature of 18-20°C and a soil temperature of approximately 22°C must be maintained. After the flower harvest, a period of growth is necessary for the development of new flower buds for the following season. The total cultivation period of plants until they are lifted again will be at least 9 months.

ASSORTMENT

There are not many varieties available for cut flower cultivation. Fortunately, in recent years there has been an increase in the number of

varieties and colors. 'Red Lion' and 'Apple Blossom' jointly comprise approximately 65% of the supply. In addition to these two varieties the following are being grown for cut flower production.

(Large flowered)	
- Minerva	red/white
- Rilona	orange
- Ludwig's Dazzler	white
- Telstar	dark pink.
(Small flowered)	
- Pygmee	orange/red
- Pamela	orange/red
- Scarlet Baby	red.

High quality requirements have to be met by these varieties so that they can be grown for flower cultivation. Not only does the variety need to have good growing qualities but it must have a good presentation at the harvesting stage in particular and, in addition, it must produce sufficient calyxes on a firm, tall stalk. The cut flower stalks must have good keeping qualities and should not have any problems during transportation.

HARVESTING FLOWER STALKS

The flower stalks are harvested when the buds begin to colour and the first 2 buds grow more apart. Harvesting too early means a product which quality-wise is poorer and the flowers do not open well or completely. So beware of harvesting too soon. The flower stalks can be cut or pulled. If they are rather short they are usually pulled. This improves the stalk length. If the flower stalks are cut, take care that the plant is not damaged when cutting. Flower stalks which are harvested from bulbs which were not lifted after the previous season are often pulled. During packing it might be necessary to shorten the flower stalk to get it into the box. The old piece of stalk which remains in the bulb after cutting will not cause any damage in plants which grow normally.

PACKING THE FLOWER STALKS

It is important to pack the flower stalks close together in sturdy boxes. To protect the calyxes, plastic mats are placed around them and, where necessary, covered with extra shredded paper. This is a very compact method which ensured the flowers remain in position and do not move, thus greatly reducing the chances of damage. The red varieties, in particular, quickly show signs of damage or bruising.

LIFTING BULBS

After the growth cycle the bulbs can be lifted, dried and prepared once more for forcing. The growing cycle then begins again. The bulbs are

sometimes mechanically lifted but it is usually done by hand. Afterwards the foliage is cut off at the point where the leaf joins the fixed part of the neck of the bulb. It is important that bulbs intended for cut flower cultivation are not cut too close to the bulb. It is better to cut the leaf off a bit higher so that the cut section is as close as possible to the natural dying off point. After removing the foliage the bulbs are placed in gauze or plastic tubs with the cut section facing upwards. There must be no soil, foliage or other contaminating substances lying on the remaining cut section of the bulb. This could interfere with the drying process.

DRYING THE BULBS

After lifting the bulbs must be placed in the drying sheds as soon as possible. Never leave in the greenhouse overnight. Minimum drying temperature is 30°C. Subsequently dry the bulbs for at least 7 days at a temperature which is at least 6°C above the temperature outside. Especially during the first 24 hours, a great deal of moisture must be removed. Good ventilation is required throughout the whole drying process. After drying, the bulbs are stored at the conditioning temperature of 13°C.

YEARLY GROWTH CYCLES

Planting to flowering	Flowering period	Growth cycle	lifting/ drying	conditioning of bulbs
5-8 weeks	≈ 4 weeks	≈ 6 months	2 weeks	10 weeks
Total growing time: ≈ 9 months			Non-growing time: ≈ 3 months	

If bulbs are lifted and subsequently replanted the following procedure should be used. Small bulbs should be sorted out when lifting and these bulbs are then forced separately.

LEAVING BULBS IN THE GROUND (NON-LIFTED)

There is an increasing tendency among the *Hippeastrum* flower growers not to lift their bulbs but to leave them in the ground where they are cooled. What are the advantages of doing this?

- no labor needed for lifting
- no containers needed for preparation
- no preparation sheds needed
- flower stalks are stronger

What are the disadvantages?

- Sometimes there is no other choice but to lift if there are problems with the health of the plants. Bulbs can be given warm water treatments against mites and root lesion nematodes that can only be carried out

on lifted bulbs.

- The removal of foliage is usually done by hand. This requires extra care.
- The sensitivity to *Colletotrichum* is higher when bulbs are left in the ground. This is a fungus which gives problems, in particular with 'Red Lion'.
- Cooling the soil also costs money.

PREPARING THE SOIL

The indispensable cooling period to break the dormancy now has to be given in the ground. The bulbs have to have at least ten weeks at a temperature of 13-15°C. During the cooling period the leaves remain on the bulb.

There are two methods of cooling:

a. Natural cooling

During the course of the autumn, the ground temperature drops to 15°C. From that moment onwards the cooling period begins. How early and effective the cooling is depends entirely on the weather conditions at that moment. Obviously, the greenhouse has to be well ventilated and screened. We have to depend on the prevailing weather conditions at this stage.

b. Forced cooling

With the aid of a cooling installation, cooled water is pumped through the sub-terranean heating hoses. This method can also be applied in the summer to establish ground cooling to 13-15°C. Depending on the weather and capacity, the ground will be brought to the temperature desired sooner or later. During the cooling period the cover of the greenhouse is shaded and, of course, frequently ventilated.

Watering during cooling: the ground must certainly not be too dry as thermal conduction (of heat and cold) is best in moist soils. Growth continues during the cooling procedure; therefore, watering a few times is advisable depending on the soil type and situation.

REMOVAL OF FOLIAGE

At the end of the cooling period, the foliage present must be removed. This is usually cut off by hand and removed from the greenhouse. There are some companies who drive over the bed with a shredding machine and shred the leaves very finely. Sometimes the shredded pieces are left on the ground but they can also be removed from the greenhouse. This largely depends on the grower's experience with this method. Some people tend to be rather cautious about this method because of the risks of fungal diseases.

It is extremely important to create optimum growing conditions after the foliage has been removed. Good and fast growth reduces the chances of fungal diseases. After the foliage has been removed, the bulbs are sometimes covered with plastic film or cloth, as previously mentioned. This is removed

after a few weeks.

HEATING AFTER THE COOLING PERIOD

When the foliage has been removed, heating can be started immediately. Some growers even begin a little earlier to hasten floral development as much as possible. The development of the flower stalk is then maximized to reduce the chance of fungal diseases. The temperature level for air and ground is the same as for bulbs which are lifted and replanted. Early in the season, September, the average greenhouse temperatures are a little higher due to the greater penetration of sun and light rays which occurs at that time. This can contribute to a shorter forcing period. When heating the ground, well moistened soil is required and, if drip hoses are being used, irrigation is started in order to increase conductivity of heat through the ground.

PLANT PROTECTION

The *Hippeastrum* flower grower will have to be particularly careful when it comes to the following diseases:

- *Stagonospora curtisii*	a fungus causing "fire" or "red blight",
- *Pratylenchus scribneri*	root lesion nematodes which cause root rot,
- *Tarsonemus sp.*	so-called bulb scale mite,
- *Fusarium moniliforme*	a fungus causing root and basal plate problems.

Figures 1 & 2 may be found on page 59.

CULTIVAR	FORCING PERIOD (DAYS)*	STALKS PER BULB**	CALYX # PER STALK**	FLOWER SIZE (CM)	LENGTH OF STALK (CM)	COLOR
RED						
Fire Dance	45	1.9	4	18	44	bright red
Liberty	45	2.2	3-5	18	53	dark red
Ludwig Goliath	38	2.3	3-5	22	45	red
Oskar	46	1.9	4	17	60	bright red
Red Lion	47	2.3	3-4	16	53	scarlet red
ORANGE						
Byoux	40	2.0	4	18	45	orange/salmon
Cicero	45	2.1	4	18	46	orange/red
Orange Souvereign	39	2.5	4-6	18	45	orange/red
PINK						
Apple Blossom	38	1.9	4-6	18	52	pink/white
Bestseller	45	2.4	4	17	41	striped pink
Cantate	43	1.9	3-4	19	48	lilac
Flower Record	40	2.0	4-6	18	56	salmon pink striped
Hercules	50	1.8	4-6	19	52	lilac pink
Suzan	42	2.5	4-6	18	39	bright pink
Telstar	47	1.8	3-4	17	39	carmine
Vera	44	2.3	4	18	45	pink
Wonderland	42	1.9	4	20	50	pink w/ white star
SALMON						
Lydia	40	1.8	4	16	48	salmon/pink
Rilona	48	2.0	4	19	60	salmon
Salmon Tower	45	1.8	3	22	60	salmon

CULTIVAR	FORCING PERIOD (DAYS)*	STALKS PER BULB**	CALYX # PER STALK**	FLOWER SIZE (CM)	LENGTH OF STALK (CM)	COLOR
STRIPED						
Cinderella	45	2.3	4-6	16	46	red/white
Happy Memory	45	2.0	4	18	59	red/white
Ludwig Striped	45	2.3	4	22	45	red/white
Minerva	45	2.2	4-6	18	50	red/white
Orion	49	1.9	4	16	51	red/white
Piquant	42	2.4	4-5	16	40	red/white
Star of Holland	50	1.8	3-4	20	55	red/white
Picotee	45	1.7	3-4	23	42	red/white
Peppermint	42	2.3	5	18	40	red/white
MINIATURE STANDARD						
Pamela	36	2.6	4	12	33	red
Scarlet Baby (Gracilis type)	35	3.0	4-5	10	44	scarlet red

*Forcing period: number of days between planting and appearance of the first blossoms.

**For the number of stalks and calyxes per bulb, the bulb size 30/32 was taken as the standard; with the exception of the varieties 'Pamela', 'Scarlet Baby', 'Peppermint' and 'Picotee', whereby the size 24/26 was taken as standard.

HIPPEASTRUM IN THE WILD IN ARGENTINA

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The genus *Hippeastrum* is one of the most popular in the family Amaryllidaceae under the commercial name Amaryllis, both as a garden plant in warm climates and as a pot plant indoors in cold climates. This gives an indication of the requirements of such plants. Hippeastrums are tropical to subtropical bulbous plants and their distribution in the wild follow closely such climatic patterns.

There has been confusion in the past between *Hippeastrum* and the genus *Rhodophiala* Presl. Besides the obvious morphological differences, the most evident being the narrow, ribbon-like leaves of *Rhodophiala* as opposed to the broad ones of *Hippeastrum*, they also have different chromosome counts. *Rhodophiala* is widespread over several types of climates, most species found in warm temperate ones with a number in cold climates, reaching farther south than any other genera in the Amaryllidaceae.

Recording of *Hippeastrum* in the wild include Central America and certain Caribbean islands and most South American countries. There is even a record in Africa. There are a few countries in South America where this genus is not present but the current felling of forests will give access to new areas and more taxa will probably be found in the next few years. It is not present in Chile, where *Rhodophiala* has the center of distribution.

Species of *Hippeastrum* in Argentina are few as compared to the large numbers found in Bolivia, Brazil or Peru. They are also poorly known although a few have been thoroughly described. There are several reasons for this. The country has been colonized by Europeans for several centuries now and most of the original vegetation no longer exists. This is particularly true in the east of the country. Additional species have been discovered in the last few decades in dense forest areas in the north where access is difficult. Also distances are very considerable for field studies and moreover, increasingly difficult economic conditions in all of Latin America have prevented the completion of the regional Floras and funding for field work is not available anymore.

MAP I

Map I shows the phytogeographical regions of Argentina related to *Hippeastrum* species distribution in the country. These are always found in tropical and subtropical areas, completely free of frost the year round or once the dormancy period is over.

Amazonian Realm	Province of the Yungas (Provincia de las Yungas)
	Province of the Paraná (Provincia Paranaense)
	Province of the Chaco (Provincia Chaqueña)
Chaco Realm	Espinal Province (Provincia del Espinal)
	Pampas province (Provincia Pampeana)

The Amazonian climate and flora enters Argentina in two zones, marked (A), (S) and (Q) in the map. Strictly speaking, only in zones (A), (S) and (Q) do *Hippeastrum* species occur in the wild, but the large rivers produce narrow subtropical corridors far south into colder latitudes as explained below. Zone (A) is a comparatively narrow corridor along the eastern slopes of the Andes. The vegetation is mainly cloud forests with a great variety of species, mostly of tall trees (about 30m) with a dense undercover of vines, epiphytes, scrub and grasses. Mean annual temperatures range from 14 to 26°C, the climate being hot and humid, with an annual rainfall of 900-2,500mm mainly along the summer months. Altitudes of 500-2,500m are covered by this typical Flora. Several tropical crops are grown in this area and even an ultratropical one, coffee, in the extreme north.

The second zone belonging to the Amazonian Realm is the Provincia Paranaense which covers most of the Province of Misiones, part of the province of Corrientes beyond to Paraguay and Brazil. Most of this phytogeographical province comprises dense forests with tall trees, palms, climbers, etc. Regrettably a huge part of it has been destroyed and replaced by pine plantations. Only in the Iguazú National Park this original vegetation survives. The climate is hot and humid with a mean annual temperature of 21°C and an average annual rainfall of 2,000 mm. Winters are mild and summers hot with frequent rains. In the southern extreme the forests change to open pastures, scrub and marshes. The same forest species reaches far south to the Rio de la Plata along the river banks. It is interesting to mention that the huge masses of water of the great rivers keep the mean temperatures high and these gallery forests frost free, thus allowing a subtropical type of vegetation to reach a more southern latitude into the pampas where frosts are common in winter.

THE CHACO REALM

The Chaco Realm, covers most of Argentina. The phytogeographical Provincia Chaqueña proper (Q) comprises mainly flat land and hills with low precipitation and hot temperatures. Vegetation is of the xerophytic type with dense forests covering part of the region, the rest being scrub, cacti, bromeliads, etc. Annual rainfall averages 500mm in the west of the region and 1,200mm in the east where it overlaps with the Provincia Paranaense (S). A

mean temperature of 20-23°C makes this a warm area the year round. (G) is the Provincia del Espinal, this word, "espinal", meaning thorny scrub. It comprises open pastures and sparse forests of low trees and occasional seasonal marshes. A mean annual temperature of 15-20°C and a rainfall ranging from 340mm (in the west) to 1,170mm (in the east) indicate this is also a warm area but with drier conditions. (K) is the region of the pampas, an area extremely rich in species, particularly of Gramineae, although most of this has been destroyed by agriculture and only relic spots survive. The pampas are huge plains with very little variations in altitude and only low hills. Annual rainfall is 600mm (in the west) to 1,100mm (in the east). Mean annual temperature range is 1-17°C. (G) and (K) have no *Hippeastrum* species and there is a relation between the lower temperatures in these two regions (as compared to that of the Province of the Yungas and the Paraná Province) and this absence of *Hippeastrum*. Despite this and, as mentioned above, because of the big rivers and the narrow gallery forests (essentially of subtropical species), it is possible to find a *Hippeastrum* sp. as far south as Punta Lara (6-A in Map III; (T) in Map I).

MAP II

Map II depicts the big river basins in Southern South America. One of them is the Pilcomayo-Bermejo-Paraguay-Paraná. The Paraná receives the waters from the Andes of Bolivia and the Brazilian plateaus, the system originating in the Amazonian jungles (as Paraguay River). The other is the Uruguay river, that begins in the coastal Atlantic plateaus of Brazil. All this immense mass of water as indicated in the Map finally pours into the Rio de la Plata and the Atlantic Ocean, having originated thousands of miles to the north, the east and the west and sustaining a subtropical Flora along its banks.

MAP III - THE SPECIES AND FORMS

Hippeastrum aviflorum and *Hippeastrum iguazuanum*

H. aviflorum was discovered many years ago by Dr. Elisa Nicora during a collecting trip in northwest Argentina. It is know from this single collection. Thanks to the efforts and interest of Mr. Salvador Magno one bulb of the type collection is still under cultivation and after a number of years it has flowered and set seed from its own pollen. This is an interesting achievement as it has not been possible to locate further wild material. *H. aviflorum* belongs to a group of closely related species or forms of a species with strongly zygomorphic flowers, the two outer, lowermost tepals being curved towards the center of the flower and strongly veinated on a paler greenish ground. At approximately the same latitude but a considerable distance east we find *Hippeastrum iguazuanum* Rav. (2). This plant is indistinguishable from *H. aviflorum*, being smaller and more slender in all its parts and having more apple green as a ground colour and paler red venation. Foliage in both "species" is very characteristic, being linear, pruinose, a grayish green with a pronounced keel and the edges typically folded back. Both *H. aviflorum* and *H. iguazuanum* have exactly the same type leaf but in *aviflorum* it is larger. *H.*

iguazuanum is a rare species with only a handful of collections known from the wild. It, also, like *H. aviflorum* is self compatible. Under cultivation both taxa present no problems and are dormant in winter. Flowering is in October to November, our spring, and the scape, appears after part of the leaves are above ground. The bulbs are found well buried in the ground, with a neck 5cm long.

Hippeastrum teyucuarensis (3) is another species or form closely related to the preceding two. It shares with them the same foliage type and colour and the same flower type. The main difference is that *H. teyucuarensis* is larger and considerably more robust. We have seen this species at the type location where it still survives in inaccessible cliffs, and also sterile forms under cultivation, some with two flowers and others with four. Such forms offset abundantly, clumps soon being formed. Obviously, the wild plants do set seed. This species was originally discovered by A. Schinini, a botanist very active in the field in Argentina and Paraguay. Under cultivation another wild collection is preserved, from Ituzaingo, Corrientes Province, now under water by the building of a huge dam on the Paraná River. This second collection is exactly like the type plants. Ituzaingo is a short distance from the type location and we hope more wild material is eventually found to obtain seed and reproduce this interesting plant for the future. Although *H. aviflorum* and *H. iguazuanum* were found in shady conditions, *H. teyucuarensis* is found in steep banks on the Paraná river many meters high and in full fierce sun. The bulbs are found buried into the ground with 5-10cm long neck.

Hippeastrum arboricolum (4) was found by a relative of the late Dr. Carlos Gomez Rupell, famous during the 70's because he collected many bulbs in many parts of Chile, Paraguay, Argentina, and Brazil for sale in the United States. This person was reportedly working for the paper pulp company that has a huge paper mill in the region and pine plantations all around. Knowing of Dr. Gomez Rupell's interest he sent him the bulbs. Although we know of two other epiphytic *Hippeastrum*, *H. aulicum* and *H. calyptratum*, the finding of a third species with this unusual habit was very exciting. *H. arboricolum* was sold to growers in the States and it is apparently lost in cultivation now. All the efforts of this writer to find this species again proved a failure. Not only is the whole area destroyed and planted with pines but also many inquiries to local people were negative. This indicates that the species is exceedingly rare and if there were more plants in the wild they may be lost by the forest felling that took place in the last two decades. The information we have of this species suggests a relation to the typical Rio de Janeiro *H. striatum*.

Hippeastrum angustifolium (5) is one of the most fascinating species of bulbous plants, being an aquatic. The large *Sprekelia*-like flowers are very unusual. During 1989, Dr. P. O'Farrell and this writer had the chance to follow this species in the wild over most of its distribution. The data gathered will serve for future planning in conservation of the species. Mr. Jorge Veit followed this species into Paraguay and this writer into Southern Brazil. In all cases it occurs in open, flat, inundated, lowland ditches and marshes, always

in running water and in full sun. It is a robust species with a tall stout scape bearing a number of flowers (up to 14 have been reported in robust plants). There is a considerable variation in flower shape some being spidery. Others have very broad tepals making for a very attractive inflorescence. Flower colour is also variable, a coral red being found at times, a very fine scarlet, a muddy pink, signal red and more purplish shades, all in one population. One or two large plants are usually found and with a variable number of offsets over a large area. These offsets appear at the tip of long runners at a considerable distance from the mother bulb. The bulbs are very large and are found deeply imbedded in the muck. Their root system is huge with thick roots, probably to keep the plants anchored during the occasional heavy floods. All the rivers, marshes and streams in the region make a dense network communicating with each other and this is the reason why this species is so widespread. It is never abundant, however, and it is highly vulnerable. A reserve or National Park would protect this plant so future generations will have a chance to see it. Attempts to introduce this plant in tropical or subtropical regions of the world could prove a success, and a good chance for survival of the species. Another interesting feature is the foliage, mimetic with several species that grow in the same marshes. The plants are evenly dispersed in the water, every ten meters or so a plant is found. When *H. angustifolium* is not in flower, it is difficult to spot it. The erect, glaucous foliage in *H. angustifolium* also has a similar height to the surrounding plants. This is, of course, very striking to see. The neck of the bulbs, up to 30cm long, is also characteristic of this species.

Hippeastrum petiolatum (6) is a natural hybrid between uncertain species that are found in Brazil along the middle Paraná River and along this river and the Uruguay River down to the Rio de la Plata, making this the species in the genus with a southernmost distribution (6A). *Hippeastrum petiolatum* is a species in danger of extinction, having disappeared from most wild locations. It does not set any seed but produces many bulblets that remain dormant for a long period. It is generally accepted that this prolonged dormancy has contributed to the dispersal of the species, the small, round bulbs floating for prolonged periods and after the flood is over, anchoring in distant locations. Wild plants are found along rivers banks often at spots where obviously were transported by floods and with the bulbs barely covered with soil. *Hippeastrum petiolatum* owes its name to the typical foliage, narrower at the base and of a shining green. It is a versatile plant under cultivation, adapted to small pots, producing abundant offsets. It has often been mentioned in the past that it is difficult to break the dormancy of these offsets. Bottom heat and moist soil is useful to encourage root growth but it is safer to leave them dormant during the winter and start them in the spring. Under warm conditions and in the wild the foliage is practically evergreen but watering the year round may prevent flowering. It is sufficient to keep the plants without any water for a month in late winter to produce blooms. In the wild it is always found in shade, indicating it is a species very tolerant to low light values.

From Dr. Gomez Rupell's collections an intriguing plant (7) was

distributed in the United States: *Hippeastrum "albostriatum"*. All we know is that it was a long trumpet of the Macropodastrum group. It was apparently collected in the wild in a hot area of xerophytic vegetation in the Province of Formosa. It is very unfortunate that practically all the *Hippeastrum* material sold by Dr. Gomez Rupell's to U.S. growers was only used for hybridizing and not to preserve the species under cultivation. Now that the wild habitats are so modified we can not find the species anymore. All efforts to locate this plant proved fruitless.

Hippeastrum parodii (8) and *H.* "Mrs. Sosa"

During the 70's a peculiar plant received considerable publicity. It was *Hippeastrum* "Mrs. Sosa". A young man that accompanied Dr. Gomez Rupell in his trips found a most unusual "Amaryllis" growing at the home of a woman and wrote mentioning this to Dr. Gómez Rupell. They finally secured bulbs from Mrs. Sosa (this was the name of the old woman who grew the plants) and sold them to growers in the States. This plant finally flowered and its pollen was profusely used in countless hybridizing experiments. As happened so frequently by that time, the bulbs were lost. The demand was so intense that Dr. Gómez Rupell had to secure more for his customers but only a second consignment was sent to them. Afterwards it was impossible to obtain more and he started losing his good health. All the efforts to find the source of the plants proved a failure as Mrs. Sosa refused to say anything about it, except that they came from Brazil. It was a sensation to have a greenish yellow *Hippeastrum* as for the first time the possibility of a yellow Amaryllis seemed at hand by using the then available *H. evansiae* and *H. aglaiae*. Many years after, this writer has 'Mrs. Sosa' under cultivation and has been able to distribute some offsets. The bulbs were obtained thanks to the efforts of the man who accompanied Dr. Gómez Rupell in his collecting trips. They are not, however, anything but a smaller version of *H. parodii*. Every feature coincides: flower shape and colour, bulb shape, thick roots, foliage shape and colour, etc. The only difference is the overall size. The origin of 'Mrs. Sosa' is still a puzzle since *H. parodii* does not occur in Brazil. It does occur, however, in Bolivia and one cannot help but wonder if it were not under cultivation in Brazil from Bolivian collected material.

Hippeastrum parodii (8) is a species found in xerophytic, hot regions in north west Argentina, its distribution extending into Bolivia. It grows in full sun in a somewhat sandy soil that has a slight alkaline reaction. By flowering time the tips of the foliage are well developed. The robustness of the plants is impressive, the massive bulbs are often found surrounded by many offsets. The glaucous foliage indicates a protection against excessive evaporation. We have a superbly thorough description of *H. parodii* by Drs. Hunziker and Cocucci made after years of studying the species. Under cultivation the species is not difficult so long as it is grown in really big pots. The strong habit and large root system demand plenty of room to spread. Black plastic containers with a loose, porous mix provide adequate conditions. In the wild

they are dormant from early winter to late spring under completely dry conditions and this pattern must be followed under cultivation. It is hardy to slight frosts while dormant.

Hippeastrum ambiguum (9) is a species or wild hybrid found over a number of countries of South America. It has been suggested that wild plants have been found in the north of Córdoba Province in central Argentina. Such reports could not be sustained, although Dr. O'Farrell and this writer had the luck of finding a white form of *H. ambiguum*. This and the striped form were always found under cultivation or near human habitation. *H. ambiguum* has long, fragrant trumpets, white with dark red longitudinal stripes and in the white form very pale flesh colour stripes on a white ground. This is a robust plant offsetting rapidly and this is the reason why it is widespread under cultivation, not being fussy in its requirements and adapting itself to a number of conditions. The foliage is very broad, shiny and long. It is dormant in winter, flowering with the first spring rains. It is also one of the hardiest *Hippeastrum* species, frosts of -10°C not harming it nor impeding flowering.

Hippeastrum argentinum (10) has been known for a long time under the names of *Amaryllis candida*, *Amaryllis tucumana* and *A. inmaculata*. It is another species found in Bolivia and extending south to the Province of Catamarca, Argentina. It is a plant from hot, forested areas. The long, fragrant trumpets with undulating edges are very typical. It is dormant in winter, flowering in late spring. In the past it was collected in huge numbers in the wild since the Dutch had great hopes of marketing it and it was regarded then as an ideal plant. This optimistic approach changed over the years and most of this collected stock died in cultivation, which was fortunate, otherwise all the wild plants would have been collected decades ago. Under cultivation the plant is not difficult, provided that big pots are used. The bulbs are large and the root systems huge and persistent. The species is hardy to slight frosts and dormant in winter. The foliage is large, glaucous and erect. The forms we have under cultivation are self compatible and produce viable seed from their own pollen. The bulbs have long necks - 20cm long - and should have deep pots.

(11) indicates the distribution of a red *Hippeastrum* species that is quite poorly known. Dr. Gómez Rupell sold it under the name 'Red Cochuna', Cochuna being the name of a river where the plant is found in the wild. The cultivated stock is practically lost and we hope that future collections will help preserve this interesting species under cultivation. We collected this species in the wild with Dr. J. O'Farrell and had the opportunity to make inquiries about its present status and former distribution. The worst threat to it comes from free-roaming pigs that eat the bulbs. We found many holes where the bulbs originally were, but we only obtained one clump of un-eaten bulbs. Comparing this clump with the hundreds of holes dug by the pigs indicates that the species will be wiped from the area. A second location, where Mr. L. Doran originally collected *H. aglaiae*, described in **Plant Life**, no longer has the 'Red Cochuna' strain. The construction of a new mountain road destroyed a large part of the population. We also found that the flower stems are picked for taking to the cemeteries, a practice that prevents the plants from sexually

reproducing. As for the affinities, it has been suggested that 'Red Cochuna' is a form of *Hippeastrum petiolatum*. The foliage is so different from that of *H. petiolatum* that it is puzzling how this conclusion was reached. Instead, it strikingly resembles the South African *Amaryllis belladonna*'s keeled leaves and the shining green colour is also the same. Under cultivation here it is an easy, robust plant that offsets well. It remains to be seen whether or not it will produce seed from self pollination. Chromosome counts of 'Red Cochuna' made years ago by Dr. Naranjo showed the average count for the genus. Plants in the wild grow in very deep shade.

Hippeastrum aglaiae (12) is one of the three yellow species known (the others being *H. parodii* and *H. evansiae*). It is of Bolivian origin extending south a great distance to central Argentina. It occurs in hot, subtropical areas growing in full sun. The bulbs have long necks and should be grown in deep pots. They are winter dormant under dry conditions. *H. aglaiae* has been under cultivation for some time thanks to the efforts of Mr. John Leonard Doran, a Herbert Medalist who spent considerable sums collecting a number of South American *Hippeastrum* in the wild. He also collected *H. parodii, H. evansiae* and many others, researching for years into their requirements.

Hippeastrum cybister (13) is another Bolivian species from hot, dry regions that occurs in this same type of habitat in Argentina. It is very attractive, having dark red flowers with green centers, *Sprekelia*-like shape and a tall scape. The large bulbs have a long neck and demand deep pots for successful cultivation. Hot conditions are important for growing this species properly and even during their winter dormancy it is recommended that the temperature does not drop below 10°C.

Other species have been mentioned as being part of the flora of Argentina, *Hippeastrum reticulatum* among them, but from our enquiries they always were found only under cultivation, never as wild plants.

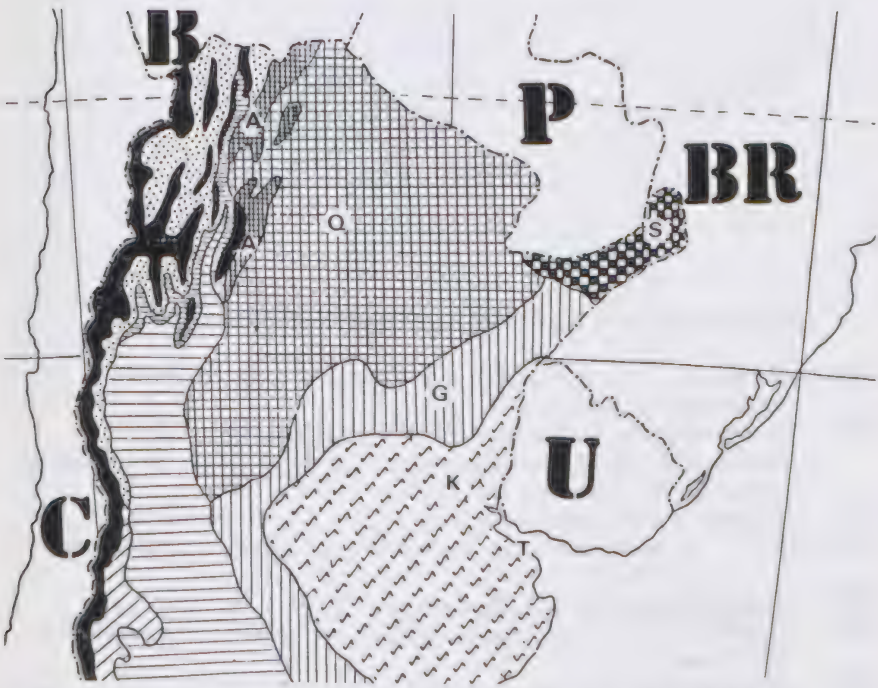
THE PRESENT AND THE FUTURE

Long gone are the times when wild populations were depleted by Dutch firms that sent collectors here to obtain thousands of *Hippeastrum* for the trade. Now Latin American human populations are booming and the need for more and more land is extinguishing more species every year, as the mass media show daily. This trend is not going to change and habitats that were thought unsuitable for agriculture and cattle grazing (who could guess that cattle could be raised in the Amazon Basin ten to twenty years ago?) are now being occupied by starving people looking for new horizons. With them they take pigs, rats, dogs and, worst of all, the goat.

Hippeastrum are as difficult to grow as any other of the Amaryllidaceae and all the problems described by Dr. Harold Koopowitz in his now famous **Herbertia** article apply to them. Under cultivation they are sometimes easy growers but one can not press too hard on them or they will die. Definitely a resting period under <u>suitable</u> temperatures should be given to them every year. All efforts should be made towards growing plants from seed under

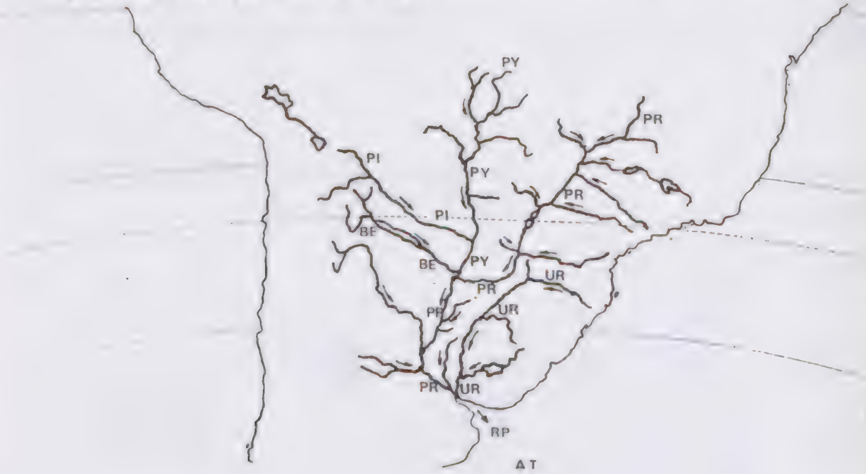
one's own conditions. They can be raised easily so long as high temperatures are maintained. From a few seeds it is possible to obtain a few species or clones and an artificial "population" can be established under cultivation. Strict sanitary conditions are most important. Try to avoid all means of virus contagion: spray against insects and rapidly isolate and destroy suspect plants.

MAPS - THE PHYTOGEOGRAPHICAL REGIONS OF ARGENTINA AND *HIPPEASTRUM*



Map I. (▲ above) A. Yungas Province. Q. Chaco Province. S. Paraná Province. G. Espinal Province. K. Pampas Province. T. Punta Lara, the southernmost location of any *Hippeastrum* species in the world. C. Chile. B. Bolivia. P. Paraguay. BR. Brazil. U. Uruguay.

Map II (▾ below). The great rivers of southern South America.
PY. Paraguay. PI. Pilcomayo. BE. Bermejo. PR. Paraná. UR. Uruguay. RP. Río de la Plata. AT. Atlantic Ocean.



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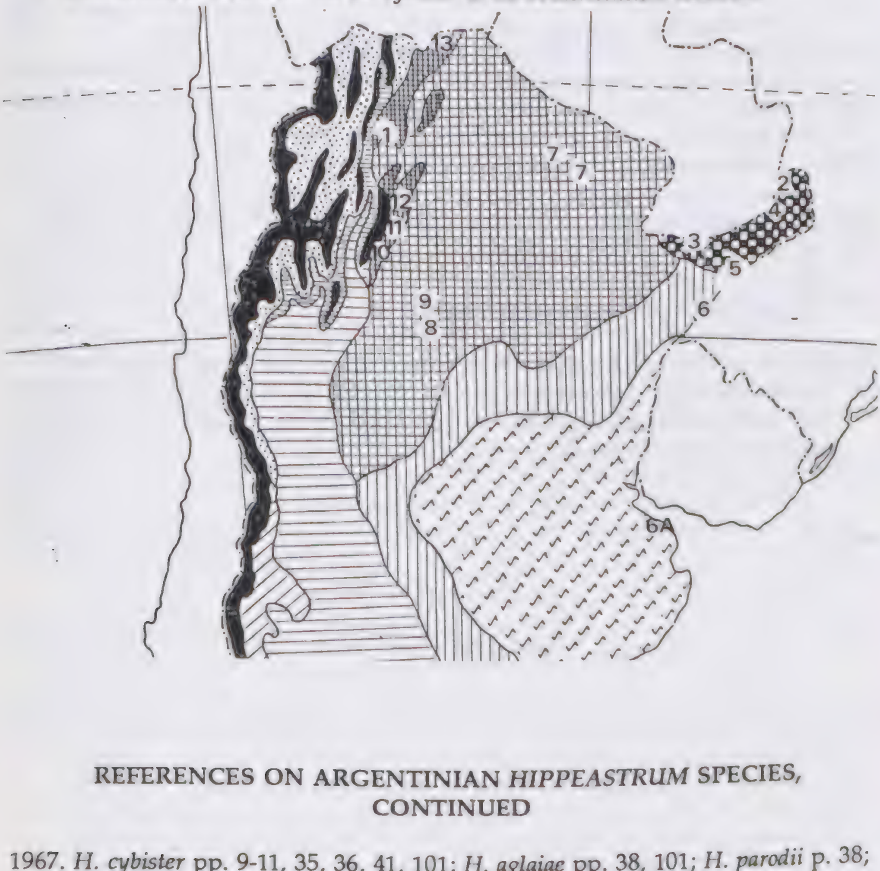
Map III (▾ below). *Hippeastrum* species and forms in Argentina.
1. *H. aviflorum*. 2. *H. iguazuanum*. 3. *H. teyucuarensis*. 4. *H. arboricolum*. 5. *H. angustifolium*. 6. *H. petiolatum*; 6A, *H. petiolatum* in its southernmost location in the wild. 7. *H. "albostriatum"*. 8. The southernmost location of *H. parodii*. 9. *H. ambiguum* in apparent wild location. 10. *H. argentinum* in its southernmost location. 11. *H.* 'Red Cochuna'. 12. *H. aglaiae* in its southernmost location. 13. *H. cybister* in its southernmost location.



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HOW TO PLANT AND CARE FOR *HIPPEASTRUM*

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The most frequently requested information at the Southern California Hemerocallis and Amaryllis Society's (SCHAS's) two annual shows is always that pertaining to the care and feeding of the plants the society displays and sells. *Hippeastrum* culture tops the list of items that show-goers ask us to de-mystify for them, so, as a service to the public we make available at shows a double sided sheet on introductory tips for growing these appealing flowers.

Southern California is largely Mediterranean in climate with low relative humidity, dry, hot summers (85-115°F), and winter/spring rainfall (except for the last 6 years of drought.) In the inland portions of Orange and Los Angeles counties and in the landlocked San Bernardino county, fall and winter are accompanied by the warm, dessicating Santa Ana winds, and snowfall is almost exclusively limited to the mountaintops above 1200-1300m. Therefore, frost protection measures in this region are minimal and bulbs are often left in the ground over winter. Also, the air's dryness limits the rate of spread of fungi that cause rots. Most of the following article is reprinted from the SCHAS flyer of the same title. Keep in mind that it is intended as beginners' guidelines for growing *Hippeastrum* (neé Amaryllis) cultivars in Southern California. Variations and adaptations to fit one's own climate should be made as needed.

PLANTING AN AMARYLLIS (*HIPPEASTRUM*)

1. Pot selection -

Choose a pot that is at least "one gallon" size (6 inches diameter, 7 inches deep) to allow room for the roots and bulb to grow. Make sure it has drainage holes at the bottom for excess water to flow out. You may wish to place a small, irregular rock, window screening, or a piece of loose polyester fiberfill over the hole from the inside of the pot in such a way that water can still drain easily but pillbugs have difficulty climbing in. (Pillbugs & sowbugs have a habit of slowly removing the soil from a pot by pushing it out the bottom.)

Note: Most *Hippeastrum* can also be planted in the ground in a frost-free place in mild climate areas.

2. Soil mix -

Many potting mixtures will do but the paramount rule of thumb is that **good drainage is <u>essential</u>!** Bulbs kept in soggy soil will rot and die, but

a well-drained mix prevents sogginess and keeps your plants happy. The following are examples of well-drained mixes.

Dee Cothran's all-purpose amaryllis mix:

silica sand	80%
peat moss (fine)	10%
vermiculite	10%

+1 tablespoon bone meal or super phosphate

A general-purpose bulb mix:

ready-made potting mix	50-75%
(avoid products that contain composted sludge or manure!)	
medium to coarse sand (silica)	25-50%

The proportions above are by volume (dry or barely damp.) Silica sand is often sold in a medium grit (#20) as "play sand" at garden/building shops. Several other grit sizes are available from specialized building supply stores. Bulbs of the *Hippeastrum* species (as you would find in the wild, as compared to hybrids bought at shows, florists' or nurseries) are usually planted in sandier, fast-draining mixtures of more than 80% sand.

Some growers recommend against the use of perlite ("Sponge Rok"). It is a mineral material containing high amounts of flouride, which can produce a leaf and root "burn" reaction in some cases.

3. Planting the bulb -

Line the bottom and sides of the pot with damp soil mixture, **hold** the bulb with one hand so that the middle of the bulgy part of the bulb is about 1/2 to 1 inch below the pot's rim and the roots are dangling down into the pot. Use your other hand to **fill in** under and around the bulb with potting mix, **pressing the mix down firmly as you go** to remove air pockets. Fill soil to about 1/2 to 1 inch below the rim of the pot, firming down as you go. 1/2-2/3 of the bulb should now be above the soil level. Now add **water**, letting excess water drain out the bottom. Watering allows the soil to settle & gives the bulb something to drink.

Do not water for a week. Overwatering inhibits root formation and stimulates root rot. Water only enough to keep slightly damp until the flower stalk has grown several inches above the bulb.

GROWING & CARING FOR *HIPPEASTRUM*

1. Starting out -

It's easy to grow amaryllis! They do all the work and give you beautiful flowers and all the cues for their easy care steps.

Put your amaryllis in a warm (68-85°F) place with bright light (not necessarily full sun.) After the initial watering but before a flower stalk begins to grow, avoid watering the bulb.

Once the stem starts to come up, water only when the potting mix is dry to the touch for about an inch down. Let the liquid drain out the bottom and avoid leaving puddles in the pot's saucer (if used) which can stagnate & cause rot. You probably won't need to water more than once a week. Flowers should appear in about 5-9 weeks after planting. The time between planting & blooming varies with the temperature. If growing indoors rotate the pot 1-2 times a week to keep the stem straight, otherwise it will bend towards the window (the strongest light source.)

2. Fertilizing -

After blooming the bulb will grow leaves and need bright light and <u>light</u> <u>feeding</u>. Growers recommend using a water soluble/liquid fertilizer high in phosphorus, such as those formulated for African violets (12-36-24, 12-36-12, 10-30-10, etc. where the proportions are for nitrogen-phosphorus-potassium.) Use fertilizers at only ¼-⅓ of the strength listed on the label, but use regularly (such as once a week in warm weather).

3. Dormancy, storage & frost protection -

In late fall your bulb's leaves will slowly start to turn yellow and then dry up. This means that the plant is going dormant. As they yellow, stop watering the plant altogether, let the leaves and soil dry out, then store over the winter in a cool, dry place that is protected from frost (like a garage, root cellar or potting shed.) If your plants are in the ground, stop watering them, then provide frost protection during cold snaps. This can be done by using a dry mulch such as straw, covering with cardboard boxes, sheets or towels or making a cold frame to retain heat.

4. What next? -

When the weather warms up again in early spring, check your plant often, as it will start to sprout on its own. It will tell you when to start watering it again by pushing up a new flower stalk or leaves. Then simply start watering & fertilizing again as you did the previous year. If mealy bugs (small, pinkish, flattened relatives of aphids with a white coating) are ever a problem, use a mild solution of insecticidal soap according to directions or slightly more dilute. Mealy bugs feed at the base of the leaves, causing leaf distortion & spreading virus.

SUMMARY

1. Plant in a well-drained mix with the bulb at least halfway out of the soil, firming to remove air pockets as you go, then watering once.

2. When the flower stalk(s) begin(s) to come up, water just enough to keep damp, letting dry slightly in between waterings.

3. When flowering is completed provide bright light to full sun and begin feeding lightly (1/4-1/3 strength) with liquid fertilizer. This will keep the leaves growing and enable the bulb store energy for next year.

4. As the plant goes dormant, stop watering, let the soil dry out, then store the bulb in a cool, dry place until it sprouts 3-4 months later.

GROWING *HIPPEASTRUMS*
(PRESENTED AT THE SEPTEMBER, 1988 INTERNATIONAL BULB CONFERENCE, PERTH, WESTERN AUSTRALIA)

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KARDINYA 6163 W.A., AUSTRALIA

PROCURING BREEDING STOCK

The best time to start growing Hippeastrum, in most cases, is when you can purchase bulbs in flower. In this situation you can make your selection for colour and good flower shape. This is very important, as it takes just as much effort to grow mediocre flowers as it does to grow [those of] exhibition quality. These days when it is fairly easy to procure a good range of colours and good quality bulb, it is ideal to start off with seven or eight selections. This will give you a chance to increase your selections with the natural increase of side bulbs. Also, you can hand pollinate and grown your own seedlings.

CULTURE

Having procured your starting stock, it is necessary to known how to look after them. To get best results from your efforts, your plants should be positioned for morning sun, or grown under 50% shade cloth. Since Hippeastrums are gross feeders, they need regular weekly feeding with a liquid fertilizer. Good results are had using either "Spring" or "Phostrogen" at recommended strength.

A monthly application of "Thimet" is necessary to combat thrips and a regular fungicidal spray to control red rust. The red rust problem diminishes in warm weather or with fungicide application. A mixture of "Benlate" and "Mancozeb" or other fungicides is necessary. These need to be mixed at recommended full strength, since one will control what the other misses -- this should give you 100% control of any fungus. Any flower spikes not intended for producing seed should be removed after blooming by cutting them down as close as possible to the bulb. Be sure to cut from the inside top in a slanting angle to the outside. This will insure the least amount of moisture lodging in the remaining section.

As the summer months go on after flowering, watering will need to vary to keep your potting mixture moist, but not wet. Weekly fertilizing is necessary to grown your bulbs on. A minimum of eight leaves per bulb is the ultimate to produce a good flowering in the next season. Your fertilizing and fungicide treatments need to be carried out until April or May (mid autumn), depending on the weather. As it gets colder you will find the leaves start to yellow off. It then becomes necessary to remove these leaves

by tearing them off in a sideways action. Do not cut off these dying leaves since cutting will cause bleeding and an invitation to fungal growth. Your bulbs will then go into their winter rest period.

(RE-)POTTING REQUIREMENTS AND METHOD

Re-potting is normally carried out in July and August (mid-winter) and requires the following:

- Clean, washed pots (treatment with diluted [10%] household liquid bleach is advised for sterilization.)
- 1 shaker of "Nemacur", 1 shaker of "Thimet" (disystox)
- labels and marking pen
- pulverized cow (or other organic) manure
- potting mix with a pH of 6-7 or thereabouts. This needs to be a fairly open mix for quick drainage, as wet roots mean root rot. When the mix is watered the water should run through the top of the pot in around 20-25 seconds.

On removal from their old pots, the bulbs are washed, dead roots are removed, then the bulbs are soaked in a fungicidal mixture for around twenty minutes. They are left to dry for the same period, leaving a residue coating on the bulbs and roots. Do not cut off the healthy roots. Select the pot size so as to leave about 1 inch all around (between the bulb and pot sides), e.g.: a 4 inch bulb in a 6 inch pot, unless root growth prevents this, in which case go up to the next size pot. Deep pots, not squat pots, are best.

Method of potting: fill the pot about 1/3 with mix, then dust with "Nemacur" and an application of manure (which will start off growth until normal fertilizing is initiated at the first sign of foliage growth.) Then, holding the bulb so that the neck of the bulb is just above the top of the pot, fill (with mix) making sure that an air pocket is not left under the base of your bulb. Shake the mixture around the roots and press down firmly. Place the pot in its selected position, "Thimet" and water lightly.

GROWING IN THE GROUND

Drainage needs to be good, fertilizer must be added and treatment as for pots must be carried out when planting bulbs in the ground. Make sure they are not planted too deeply. Positioning *Hippeastrum* so that they receive morning sun is recommended.

GROWING *HIPPEASTRUM* FROM SEED

Growing from seed is a very rewarding venture. To pollinate your own seed it is necessary to select two good, different flowers. Light to light or dark to dark. When the stigma is ripe it will turn upwards and split into three lobes. Remove pollen from the selected plant and thoroughly dust it on the stigma of the other selected plant. It is then necessary to place it in an area away from insects, such as an enclosed patio, until the ovary at the back of the flower starts to show signs of swelling. The pot can be put out

into the normal growing area. After about eight seeks the large seed pod should start to go yellow and split open. It should then be picked, opened up and left to dry for at least three days before the seeds can be planted.

There are several methods of propagation. One is to start the seeds off in an ice cream container 1/3 full of a damp mixture of peat moss and old sawdust or coarse sand. Lay seeds on top and cover with 1/8 inch of peat moss, put on the lid and place in a warm area. Germination should be in around 10 days. Don't leave the lid off until they reach germination. Keep damp, not wet, when the second leaf appears. These seedlings can be planted out into multi pots using the normal potting mix with 14 plants in a 200mm pot. In most cases they can be left there for 18 months (treated as for mature bulbs.) Seedlings don't normally lose their leaves until they reach flowering size. Then they are moved to their own single pots at 2-3 years after germination, depending on how they are cared for.

The second method of germination is to plant seed directly into large pots at around 14 per 200mm pot. The third method of germination is for seeds to be planted in 2 inch deep trays which can normally be left 5 or 6 months before planting out into small, individual pots or multipots.

This should lead to happy and successful growing.

AMARYLLIDACEAE: FLORA OF ECUADOR

Dr. Alan Meerow, a member of the International Bulb Society Board of Directors, researcher of the Amaryllidaceae, and faculty member of the University of Florida, Fort Lauderdale, is a contributing writer to the "Flora of Ecuador", which has just been published. In his treatment of the Ecuadorean Amaryllidaceae in the Amaryllidaceae volume, number 41, volume 202, of the Flora of Ecuador series, Dr. Meerow recognizes 11 indigenous and 2 exotic genera which occur in Ecuador. This treatment of the Amaryllidaceae spans 53 pages with quality line drawings and two pages of excellent color photographs, as well.

It should be noted that Dr. Meerow is currently conducting in depth research in preparation for writing a comprehensive, unifying presentation dealing with the genera of the Amaryllidaceae. The Amaryllidaceae edition of the Flora of Ecuador series can be purchased for $31.00 US from Nordic Journal of Botany, Ø Farimagsgade 2D, DK-1353 Copenhagen K, Denmark.

AMERICAN *CALOCHORTUS* SOCIETY

The American *Calochortus* Society publishes a quarterly newsletter, **Mariposa**, containing announcements, trips, germination tests, cultural tips, book reviews, and conservation articles concerning the genus *Calochortus*. It also highlights a different species of these lovely California native plants in each issue. (If you are unfamiliar with them, see "The Genus *Calochortus*", **Herbertia** 46(1&2):42-43.) Those interested in subscribing to **Mariposa** may contact its editor, H.P. McDonald, for information at the following address:

American *Calochortus* Society
260 Alden Road
Hayward CA 94541
United States of America.

Presentation of The Herbert Medal to Dr. Kenneth E. Mann, April 27, 1991

HERBERT KELLY, JR.
10266 E. PRINCETON, SANGER, CA 93657
UNITED STATES OF AMERICA

Through unselfish devotion to the Southern California Hemerocallis and Amaryllis Society and the International Bulb Society (formerly the American Plant Life Society), Dr. Kenneth Mann has helped to foster a better understanding of the bulbous plant kingdom and has delineated many goals yet to be achieved. These societies are now prospering with renewed vigor due in large part to Ken's enthusiasm and self sacrifice. Ken has loved the bulbous plant kingdom with a passion and nothing has given him greater pleasure than sharing his knowledge and botanical treasures with everyone he has come in contact with.

It is with all of the above in mind that on Saturday, April 27, 1991, the International Bulb Society met at Descanso Gardens to present to Dr. Kenneth E. Mann the prestigious Herbert Medal in appreciation of his contributions and unselfish devotion to all of us. Our lives have been enriched by his presence and many of us will be eternally grateful for having known him.

Herbert Medal Presented to Dr. H. Shuichi Hirao

The 1990 Herbert Medal was awarded posthumously to Dr. H. Shuichi Hirao by the International Bulb Society in June, 1991 in recognition of his lifetime achievements in hybridizing and collecting petaloid monocots. He was renowned for his amaryllid collections and for his hybridizing achievements with Japanese iris (including *I. ensata*), *Nerine*, *Sparaxis* and other plant genera. Dr. Hirao was employed by the Japanese Department of Fisheries and was a specialist in pigmentation of fish. He was an individual who inspired many plant growers and was always generous in sharing his hybrids and growing stock. Dr. Hirao's son accepted the Medal on his behalf.

Ken Mann: An Autobiography

I was born in St. Louis, Missouri on May 3, 1933 to Ruby Opal and Edgar Russell Mann. My father was born in Arvonia, Virginia in 1900 near the slate quarry where his father worked as a machinist. He joined the Marines in 1918 and was stationed in St. Louis, Missouri until discharged in 1920. He remained in St. Louis the rest of his life. My mother, Ruby Wilkerson, was born in 1912 and raised on a farm homesteaded by her grandfather in Pulaski County near Crocker, Missouri. Her grandfather and father were carpenters and farmers.

Both of my parents were amateur gardeners. My father was active in the Men's Garden Club of St. Louis. A hybridizer of daffodils, day lilies, and iris, he was a registered judge of daylilies, iris, daffodils, and vegetables.

I attended Dewey and Mason grade schools in St. Louis and Southwest High, also in St. Louis. I was awarded a B.S. with majors in mathematics and physics at University of Missouri, Rolla in 1955; and a M.A. in mathematics at University of Missouri, Columbia in 1959. In 1959 I married Jeanette Williams of Roach, Missouri. Our daughter Kathryn Eileen was born on April 11, 1960; our son Stephen Alan was born on July 24, 1963, and our daughter Rachel Elaine was born August 13, 1965.

I received a Ph.D. in physics at University of Missouri, Columbia in 1969 and from 1969-71 I served as a post-doctoral fellow at the University of Missouri, Columbia. In 1971 I was appointed Visiting Assistant Professor of Physics at the University of Wisconsin, La Cross for one year. In 1973 I moved to California where I accepted a position at the Jet Propulsion Laboratory (JPL) in Pasadena as a Senior Engineer. I am presently a member of the JPL Technical Staff. The projects I have worked on include Voyager, Craft/Cassini, and Galileo.

Jeanette and the children did not follow me from Missouri to California until 1976, 2½ years after my move, when she obtained a position at California State University, Northridge as an administrator. Looking for things to do nearby while in the absence of my family, I noticed that the Los Angles State and County Arboretum (LASCA) in Arcadia had weekly flower shows in the spring. In 1974 I attended nearly every flower show at the Arboretum and at Descanso Gardens, La Cañada.

SOUTHERN CALIFORNIA HEMEROCALLIS & AMARYLLIS SOCIETY

In Missouri I had been growing daylilies since the middle sixties and, thus, I

was particularly looking forward to the annual Southern California Hemerocallis and Amaryllis Society Show. At that time there was an amaryllis show at the Los Angeles County Arboretum in April and a daylily display in June at Descanso Gardens at the Hospitality House. The latter was conducted entirely by Quinn Buck with flowers from his acre lot in Arcadia, California.

Since the Society was a joint society for amaryllis and daylilies, both were displayed at each show. At the first amaryllis show that I attended, the only daylilies were in a few pots at the back of the room. They were attentively watched by Quinn Buck, who immediately struck up a conversation with anyone who showed any interest in daylilies and invited them to join the Society. I became fascinated by a pot of small amaryllis, exhibited by Dee Cothran, with about thirty spikes. My interest in amaryllids grew steadily from that small pot of Dee Cothran's.

Thanks to the invitations of Quinn Buck, Dee Cothran, and Gladys Williams, I joined the Southern California Hemerocallis and Amaryllis Society (SCHAS) at the first show I attended. After Gladys Williams ceased to be active in the Society in the mid-seventies, I was appointed show chair and senior judge. I have served in this capacity since then. Figure 1 shows Gladys Williams and Kenneth Mann at a SCHAS Amaryllis Show at LASCA during the 1970's. (Photo by Robert Zimmerman.)

1983 BULBOUS & CORMOUS PLANT SYMPOSIUM

In 1983 while serving as president of SCHAS, I received a letter from Dr. Hamilton P. Traub. Since this was the 50th anniversary of the American Plant Life Society (APLS), he wanted to be sure that the Society (SCHAS) would have a show to commemorate the event. He was concerned because SCHAS had not had a show in 1982 due to the illness of some of the major exhibitors. I thought to myself, "I am 50 this year and I should do something to commemorate the two events." I decided to ask Dee Cothran if he, as a very influential member of the Board of Directors of SCHAS, would support sponsoring a symposium to commemorate the founding of the APLS. He indicated he would. Since it would not possible for one person to organize such an event, I asked Jim Bauml, taxonomist at the Los Angeles County Arboretum, if he would work with me on putting together a symposium. When he said he would, I contacted Dr. Thomas W. Whitaker, Executive Secretary of the APLS, to determine if the Society (APLS) would be interested in supporting such a project.

The Board of the SCHAS agreed to allocate $700 to help cover expenses with three conditions: 1. that Marcia Wilson be awarded the Herbert Medal at the Symposium; 2. SCHAS would pay for half of her air fare if the American

Plant Life Society would pay for the other half; and 3. the registration fee for the symposium be limited to $5 to insure that all members of the SCHAS Society would be able to afford to attend. The APLS agreed to these conditions as a co-sponsor and provided a mailing list of potential attendees.

Jim and I, in consultation with Harold Koopowitz, Director of the University of California, Irvine Arboretum, and Fred Meyer, a major grower of bulbous cut-flowers in Santa Barbara County, decided that the theme of the Symposium should be species bulbs and it would feature presentations by speakers who had recently returned from the field. Now came the problem of planning the program. We agreed to have the Symposium on November 12, 1983 at LASCA. Speakers were selected based on recent trips to the field to collect and observe species bulbous plants. We tried to include speakers from all areas of the world were species grow — North America, South America and South Africa. Time was allocated in the afternoon for presentations by commercial growers of bulbous plants. In addition to seven invited papers addressing the theme of the Symposium, time was set aside for shorts papers on topics of interest to the participants. Since this was the first symposium, we had no idea whether or not people would be interested accepting the invitation to present papers. To our surprise not only did no one turn us down but we had more proposals for short papers than there was time available.

In order to publicize the Symposium, Jim Bauml and I initiated a series of newsletters for SCHAS. I would draft copy for a newsletter on the Symposium and give it to Jim to edit it for the botanical content; I would then rewrite it and give it to my wife Jeanette to edit it for grammar. The newsletter would then be mailed to all members of both societies. One of the main features of the newsletters was announcements of the donation of rare species bulbs. Leonard Doran, Ken Robertson, and others came to the financial rescue of the Symposium with the donation of a large number of rare amaryllids to be used for raffle to support the Symposium.

Due to the death of Dr. Traub during the planning period for the Symposium, the program was changed so as to honor him as founder of the American Plant Life Society (APLS) and editor of its yearbook for 49 years. Dr. Whitaker agreed to present the history of APLS and to include a biographical sketch of Dr. Traub. Figure 2 shows Dr. Whitaker, Executive Secretary of APLS and Dr. Kenneth Mann. (Photo by Jim Bauml.)

The two weeks before the Symposium were very stressful. Marcia Wilson, who was to receive the Herbert Medal and deliver the Herbert Medal Paper, died. Thad Howard graciously agreed to take Marcia's place and to present a paper. We were able to include Thad's name among the presenters in the last newsletter before the Symposium. In addition, we had more confirmed

speakers than we had pre-registered attendees.

The rainy, drizzly day of the event did not dampen the spirits of the seventy-five people who attended the Symposium. Everyone agreed that all the presentations were outstanding. The sale of the rare and unique bulbs donated for the raffle generated enough funds to cover the expenses of the Symposium.

RESULTS OF THE 1983 SYMPOSIUM: HOW THE APLS/IBS SYMPOSIUM SERIES CAME INTO BEING

Because such excitement and enthusiasm was generated by the 1983 Symposium for everyone involved with the event, speakers and attendees alike, the Board of Directors of APLS decided not to wait another fifty years to hold the next Symposium. They agreed to attempt to sponsor a Symposium every two years at different sites where there was an interest in bulbous plants.

In 1985, APLS, in conjunction with the Men's Amaryllis Club of Greater New Orleans, Louisiana, hosted the second Symposium. In addition to the presentation of excellent papers, arrangements were made for attendees to visit several private gardens in the area. For the first time growers and bulb enthusiasts from outside the country attended.

In February, 1989, APLS, in conjunction with the University of California, Irvine Arboretum, sponsored the third Symposium in Irvine, California. All six of the inhabited continents were represented among the approximately 150 people attending this event. (Figure 3 shows Les Larsson, of Palmyra, Australia, and Kenneth Mann standing in front of a *Doryanthes excelsior* in the Australia section of the Huntington Botanical Gardens in San Marino, California. This picture was taken during her visit to California to attend the 1989 Symposium and the SCHAS show. Photo by Joe Larsson.) Two days were devoted to the presentation of invited papers and a plant auction. Rare bulbs were donated by Alan Meerow, Ken Robertson, and Leonard Doran, and the L.A. State & County Arboretum.

REFERENCE

Bauml, James and Dr. Kenneth Mann. Report on the 1983 Symposium on Amaryllidaceae. Herbertia 40:42-44.

◂ Figure 1. Gladys Williams and Kenneth Mann at a SCHAS amaryllis/ *Hippeastrum* show at LASCA during the 1970's. Photo by Robert Zimmerman.

Figure 2. Dr. Thomas Whitaker (right), Executive Secretary of APLS and Dr. Kenneth Mann (left) in 1983. Photo by Jim Bauml. ▸

◂ Figure 3. Les Larsson, of Palmyra, Australia, and Kenneth Mann standing in front of a *Doryanthes excelsior* in the Australia section of the Huntington Botanical Gardens during her visit to California to attend the April, 1985 SCHAS *Hippeastrum* Show. Photo by Joe Larsson.

For figure 4 (Ken Mann, 1991 Herbert Medal winner, in a photo taken by D. Litman in December, 1990) please see the bottom of page 59.

EFFECTIVE POLLEN STORAGE PROCEDURES

In the hybridization of many crops, including bulbous ones, the need often arises to store pollen. The main reason for one to store pollen is to have it available for future use on a maternal parent that does not bloom simultaneously with the paternal plant. Therefore, proper storage conditions are required to extend pollen life. Temperature and humidity control techniques have long been applied to both seed and pollen to extend their inherent period of viability.

Many methods have been in use over the years, such as freezing or refrigeration of either desiccated or non-desiccated pollen or seeds. The basic requirement for prolonged storage is desiccation prior to and during cold storage. It is critical that materials be well dehydrated prior to freezing so that crystallization of water stored naturally within the pollen or seed does not destroy the integrity of the tissues. The desiccant I prefer is "Drierite", calcium sulfate with a colored indicator (a cobalt salt) incorporated into it for determination of the effectiveness of the desiccant. Anhydrous "Drierite" is blue and changes to pink as it becomes hydrated (absorbs moisture). When the color starts changing to pink, replace with (blue) active, dehydrated material. The desiccant can be renewed many times by oven drying until it changes back to blue. Store unused "Drierite" at room temperature in a well sealed container such as a canning jar (mason jar, etc.) with its rubber seal intact on the lid. Once proper desiccation is achieved and maintained, freezing can commence.

POLLEN PREPARATION

The use of a suitable forceps to harvest the pollen will facilitate matters. I use the dehisced (partially dried and split open to expose the pollen) anther with its attached pollen grains for storage. Pollen can be collected in several ways — either by carefully removing the dehisced anther from the plant directly or collecting the non-dehisced anther (which has not shed its pollen) and maintaining it in a humid, warm environment on waxed paper until the pollen has been shed. I use a gelatin capsule, usually the 000 or 00 sizes, to contain/confine the anthers and/or pollen during drying and storage. The gelatin walls of these capsules act as a membrane, letting the moisture of the enclosed pollen pass through to be absorbed by the desiccant. Pollen filled capsules are put into an air-tight container along with the desiccating agent. Air tight vials about 2½ inches tall and ½-1 inch in diameter (about 20ml volume) well serve this purpose. I use an adhesive, plastic label and permanent marking pen for identifying the contents. Paper labels slowly peel away from the vials because they are affected by condensation. Let the individually sealed vials stand at room temperature

for 24 prior to freezing or refrigeration.

COLD STORAGE AND POLLEN RETRIEVAL

Organization of the storage freezer is highly encouraged. When a required pollen vial is needed from the freezer, work quickly to locate the desired vials. Good organization cuts down on the time you spend hunting for a vial and, thus, prevents thawing and temperature fluctuation in the freezer. Temperature fluctuations can shorten the lifespan and viability of pollen. The ideal freezer is a chest type with the door opening up. If this is not available, a system in which a clear master container encloses the vials will help maintain temperature when the freezer is open.

Use a hand carried cooler/ice chest with ice at the bottom to transport the vials to the location where they will be needed. Keep the cooler closed when not in use. Do not let the vials heat up as a result of exposure to excessive temperatures or light. Once finished with pollination, return pollen vials to the freezer or maintain them in the refrigerator. you can probably re-freeze them 3 or 4 times on most crops and still retain sufficient viability (assuming that they are properly desiccated.) Viability of pollen, once placed in the refrigerator after harvesting or defrosting, can safely be retained for about 2 months. Any storage after this period is questionable and the use of freezing is indicated.

Through trial and error one can modify these procedures and materials to meet specific demands. Frozen pollen should probably be useable for at least one year. If you need to ship pollen to different locations, I would recommend doing so in a sealed styrofoam container with frozen ice packs included. Use sealed ice packs so that water leakage does not occur. Put the insulated container in a strong master box so that cracking or puncturing does not occur during shipping. It is highly preferable to use overnight delivery services.

SOME SOURCES FOR SUPPLIES & MATERIALS

1) Small, air tight vials and
2) "Drierite" indicating type desiccant (10-20 mesh) manufactured by W.A. Hammond Drierite Co., Xenia Ohio:

   Either local chemical and scientific suppliers or mail order suppliers such as Sigma, Aldrich, or Fisher, will stock these.

3) Gelatin capsules (sizes 000 or 00) made by Eli Lily & Co., Indianapolis, IN 46285, United States of America.

   These may be obtained at your local pharmacy in boxes of 100.

BREEDING OF *HIPPEASTRUM* IN JAPAN

SATOSHI KOMORIYA
KOMORIYA NURSERY, LTD., 1196 OHKIDO-CHO
CHIBA CITY, CHIBA PREF., JAPAN 299-31
FAX 04757-4-5154

I am 53 years of age, but my interest in bulbous plants was triggered in my high school days. At that time I read an article in a Japanese horticultural magazine regarding daffodils in the United States. The author of this article detailed how much satisfaction can be gotten from plant breeding. The impression this article left inspired me to commence collecting and breeding various species of daffodils.

Although I was initially absorbed in daffodils, I more recently turned to the acquisition of southern African bulbous plants. My interest in the collecting of the southern African continues with my breeding of *Nerine* and *Lachenalia*. The bulk of the *Nerine* hybridizing is with the species *Nerine sarniensis*, but I am now using *N. undulatum, N. flexiosum, N. pudicum* and *N. bowdeni* to produce two stems per bulb.

With the help of the late Marcia Wilson of Texas, my *Hippeastrum* collection began. She was kind enough to supply me with the initial species for my collection. I have continued to build my collection through acquisition from specialty nurseries and other contacts. In Japan the most common *Hippeastrum* are the large, round petalled varieties from Holland. Often seen in gardens are forms with red ensiformed, spotted petals.

My original interest in breeding within the genus *Hippeastrum* was to produce small bulbs which would lend themselves to use in 12cm or smaller pots. My interests have since expanded and my current objective in hybridizing *Hippeastrum* is to use all of the possible germplasm to achieve every conceivable variation.

HYBRIDIZING GOALS

I. Fragrance

Since some of the species are fragrant, introgression of this trait into all forms and sizes should not be particularly difficult. Already a tall, rose-red, round petaled, medium sized form with a green throat exists named 'Fragrant Lady'. There are also fragrances in some of the smaller varieties.

II. Narrow petaled forms

The creation of narrow petaled forms resembling *Sprekelia* but in an array of colors could be achieved through the use of species like the spidery petaled *H. cybister*. The use of this species would greatly aid in this goal because it has several color forms (pink, red, green, white).

←
Left: 2-2-1, *Hippeastrum reticulata* hybrid, salmon pink.

→
Right: 4-14-1, a medium-small, lemon yellow.

Above: #1-D-2 showing slender, white petals. This cultivar has been named 'New Look'

Above: #4-16, a medium to small multiflowered type with the variety name 'Mr. Komoryiya'

Above: The fragrant, small flowered #4-15, an intense pink.

Above: #4-17-1, *H. reticulata* hybrids of various colors.

←
Left: #5-4, 'Tenshi', a white cultivar.

→
Right: #1-E's medium sized, trumpet shaped blossoms with cherry spots on a white background.

←
Left: 'Odoriko', #5-2, displaying red & white patterning.

→
Right: #1-D-4, a medium sized white with salmon pink.

←
Left: the fragrant, pink tinted, white trumpets of #2-10.

→
Right: #5-3, 'Maiko'

III. Trumpet types

Since a fair number of species and some cultivars have funnel or trumpet shapes, the creation of a spectrum of color in this form seems fairly easy to achieve.

IV. Double forms

Double forms have long been discussed and bred in the United States. Large doubles require a sturdier stem and pedicels to support the extra weight of the flower. When used as a pot plant, shorter, wider and thicker leaves are needed to create a more overall balanced appearance. Medium and small flowered doubles would be of great interest and should be pursued.

V. Orchid types

A parent which can be used is *H. papilio*, but when crossed with a large flower type, the results would be too grotesque. Smaller ones of this type should produce lovely flowers with many interesting patterns. I have already produced some excellent hybrids of this type.

VI. Cut flower types

The flower of this group should be medium sized with round petals and tall stems. The flower stem should not be excessively thick, buds should be clear colored and held upright. 'Fragrant Lady' of rose red petals and a star-shaped green throat, the pure white 'Angel', 'Maiko' with three white outer petals and three white and pale pink inner petals, and 'Odoriko' with white flushed red are all siblings. They are ideally suited for cut flowers.

VII. Hanging types

A hanging type takes advantage of soft and feeble pedicels which would otherwise be considered as a defect. In this particular case the outer face of a flower is to be viewed and improvements would not necessarily be made on the inside colors, but, on the contrary, on the outward sides of the petals. There are few of this variety yet.

VIII. Upward facing types

There are few species which could contribute the trait of upward facing flowers. One which has already produced progeny of this type is *H. starkii*. It has resulted in medium sized upward facing types but there is still a need for large flowering types in this class with sturdy pedicels. The small- and medium-flowered sizes would benefit from an overall fuller appearance; six or more flowers per stem would seem ideal for creating a full umbel.

IX. Multiflowered

It would be a gorgeous sight to see a plant with two scapes of 10 flowers per scape simultaneously. A multi-flowered type would require

thick and compact peduncles to provide the needed support. If I create a cultivar which has 15 flowers each on two scapes, I will name it after myself.

X. Variegated leaves

Currently only variegation of an irregular nature occurs. Consistent variegation would be much more desirable. The leaves should be compact, with even variegation. Already in existence is a species which has a white midrib, *H. reticulatum* 'striatifolium'. Primary hybrids with this species result in a dilution of this feature (i.e.: less conspicuous midribs.) The way to regain the clean midrib would be by back crossing to the species or by depending on segregation in subsequent generations.

XI. Extended flowering season

Fall blooming types could be achieved by incorporating genes of *H. calyptratum*. This interesting species produces a sweet nectar and could be the basis of a "honey" series. Winter flowering, summer flowering and year-round flowering plants would also be desirable for year round enjoyment of *Hippeastrum*. With the use of a temperature controlled greenhouse, further breeding to promote year round use of this spectacular genus would be possible.

XII. New colors

Currently it appears that the "blue" *Hippeastrum* would be unobtainable. Yellow, however, is a different story and it will be a matter of time before a large flowered type and more intense yellows are realized. There already is a novel variety named 'Stained Glass' which is a clear, reddish pink color with spots. Color improvements on *Hemerocallis* in America are outstanding and it is readily conceivable that improvements on *Hippeastrum* would be far more dramatic.

All my work is being done in a controlled environment with temperatures of 15°C or higher. I feel that use of greenhouses is imperative to controlling the spread of virus. The use of *Sprekelia* in breeding might be useful to convey its immunity to virus. This soliloquy is from my viewpoint as an amateur breeder. I would most appreciate hearing from readers for their criticisms and comments.

←
Left: #1-D-6 has large, double, red flowers on a compact plant.

Above, right ↗ : #4-17-2 showing siblings in three different colors with large, double flowers.

←
Left: #3-P, an exotic looking, medium sized, red & white double.

Above, right ↗ : #2-2-2 displaying extremely slender petals of whitish pink shaded with red.

←
Left: 'Red Monkey', a *Hippeastrum-Sprekelia* cross cultivar.

→
Right: The large, pure white, upward-facing flower of #2-3-1.

«»

THE GENUS *HAEMANTHUS*

(REPRINTED FROM THE FALL, 1991 UCI ARBORETUM NEWSLETTER)

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The genus *Haemanthus* of the family Amaryllidaceae comprises some 21 species distributed throughout South Africa and Namibia. Of these 15 are found in the winter rainfall areas of South Africa, with 5 species known from the eastern, summer rainfall parts of the country. In the winter rainfall types most species are localized in areas of extreme aridity, namely Namaqualand to the north and Vanrhynsdorp in the mid-western Cape region. Typically plants of the genus produce 2 leaves each year. However, in the evergreen species of *H. albiflos* and *H. deformis*, leaves often persist from year to year resulting many times in 2 to 3 sets of leaves being present at once. Leaves can be either smooth or lightly to heavily pubescent. All species possess somewhat large, distinctive, true bulbs which are tunicated and fleshy. The tunics, formed by the leaf bases, are added each year, thus forming a succession of layers as the bulb matures. Flower color varies from white to pink in the summer rainfall species and mostly pink to red in the winter rainfall species. They are borne in an umbel surrounded by bract-like appendages called spathe valves, which are taxonomically very important in species determination. The flower itself is actinomorphic (equally divided by any plane) and often will bloom before the leaves emerge. The fruit (seeds) are berries which when ripe are soft, pulpy and range in color from white to yellow and orange.

The most common species of *Haemanthus* is *H. albiflos*. Two main reasons for its availability are its evergreen habit and ease of cultivation. It offsets regularly, making commercial propagation worthwhile. Along with *H. deformis*, all the other species are dormant & deciduous either in the summer or winter, depending on the rain cycle. *H. sanguineus* is probably the most recognizable of the winter rainfall group. Once called *H. rotundifolius* due to its two huge, rounded stiff leaves lying nearly flat on the ground, it was collected and cultivated in Europe as far back as the early eighteenth century. The flowers vary from pink to the more common bright-red, with a stout, wine red colored stem (peduncle). *Haemanthus coccineus* is the most widely ranging and variable species of the winter rainfall varieties. It was among the first plants gathered by visitors to the Cape of South Africa (early illustrations date to 1605.) *H. coccineus* was popular in Europe in the seventeenth and eighteenth centuries, being called "Cape Tulips" with the Latin name *Tulipa capensis* at the time.

The only major pests of *Haemanthus* are the dreaded mealy bugs. These should be especially looked for when the bulbs are dormant (& most vulnerable). It is best to do a routine spraying just before dormancy sets in to help eliminate this problem. The bulbs are also more prone to mealy bugs if lifted during their dormant rest period. Soil types can vary with the species but a well drained sandy mixture with proper care to not over-water is usually sufficient. Fertilize sparingly. Most species like a fair amount of light but avoid direct, hot sun. *H. albiflos* does better in a shaded position. *Haemanthus*, in general, are easy to grow and offer both unusual flowers and interesting foliage. Hopefully we can catch up with seventeenth century Europe and discover these unique beauties for ourselves. Reference: Snijman, Deirdré 1984. **A Revision of the Genus *Haemanthus*** (**Journ. South African Botany** sup. vol. 12).

Hippeastrum (Amaryllis) Growing

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From correspondence and visits with growers in many parts of the world I have heard of many troubles and heard statements like: "I can't grow this species because it is too hot here — or too humid — or some other reason." Having grown, maintained, and bloomed over 125 variants and types of more than fifty species, along with many hybrids, I would like to discuss some growing practices that might be helpful.

The primary faults I have tried to overcome and observed also with other growers are:

1. improper watering,
2. over fertilizing,
3. too much organic material in the potting mix,
4. insufficient light,
5. lack of proper vernalization.

1. SOIL MOISTURE

Material in a pot is not at all like the soil in a field. When a pot is saturated with water it remains saturated and does not drain out, a condition the plant never encounters in its habitat. An analogy would be a pot containing a sponge saturated with water. Soil in a field is rapidly reduced from the saturated condition by the "blotter" action of the surrounding soil and subsoil. This rapid reduction after a rain or irrigation aerates the soil. For this reason watering practice becomes the most important aspect of culture of plants in a pot. My observations have been that most growers do not let the pot dry out sufficiently before watering. From a number of trials we have found [that] the plant should go to 40 centibars [of water tension] or more before watering. I have run plants to 60 centibars with no problems. When using sandy soil, if one digs ½-1 inch deep, 40 centibars of tension appears barely moist, i.e., you can just tell that it is moist while the soil above is dry. For further discussion of this see Holly, W.D. and Baker, Ralph — "Carnation Production 1963", p. 57-59, Wm. C. Brown Co., Inc. and "Soil, the Yearbook of Agriculture 1957", p. 49-60, U.S. Printing Office, Washington D.C., [United States of America]. Of course, the acquisition of a *tensiometer* would be the best way to teach oneself how to water. Tensiometers are available from many sources. Two are: Randolph Matson, 1954 Camino Loma Verde, Vista CA 92083; and Irrometer Co., Inc., P.O. Box 2424, Riverside CA 92506. [Ed. note: these addresses were supplied in 1974 and may no longer be viable.] The electrical conductance instruments are usually reliable if calibrated against a

tensiometer in the same soil and fertilizer program.

It is important that when a pot is watered it should be thoroughly wet and enough water put in so a good quantity runs through. If water supply is in any way saline (don't overlook the fertilizer salts) the amount run through should be ample to insure no saline build up.

2. SOIL FERTILITY

We have over the past few years run a number of trials in an effort to determine the requirements of mature bulbs and seedlings. Seedlings of *Hippeastrum fusca* were grown in 3 inch pots and fed at every watering 90, 180, 250, 320, 390 parts per million N [nitrogen] with 36 ppM P_2O_5, 72 ppM K_2O with no essential difference in size. The seedlings showed good growth. The ones on the higher nitrogen feeding showed no ill effects. These would seem to indicate that amaryllis [*Hippeastrum*] are not sensitive to high nitrogen supply and also shows they do not require large quantities of nitrogen. Of course, there is a possibility of other limiting factors. Many "Dutch hybrids" have been grown with leaves 8cm wide and 1¼ meters long which produced 30-40cm circumference bulbs with only 75 ppM N for May, June and July. The use of soil, effluent and tissue analysis have indicated need for only mediocre amounts of phosphorus but large requirements for potash. The last couple of years I have used 75 ppM N, 40 ppM P_2O_5, and 50 ppM K_2O until about August 1st, then the formula is changed to 50 ppM N, 25 ppM P_2O_5, 100 ppM K_2O. In early September change to 100 ppM K_2O; in October, clear water. For those who wish to compute their own liquid feed, multiply the percent of fertilizer by 75 to get ppM in 100 gallons for every ounce used.

Example: calcium nitrate is 15.5% N, $0.155 \times 75 = 11.6$ ppM N when one ounce is put in 100 gallons of water.

Osmocote 14-14-14 in ½, 1, and 2 teaspoon rates have been put in pots of hybrids to compare with liquid fed bulbs. These bulbs also received the same liquid feed. No increase in growth was noted, leading to the conclusion that the liquid feed supplied all the requirements of the plant. The source of NPK is all from inorganic salts: KNO_3, $Ca(NO_3)_2$, $NH_4H_2PO_4$, and K_2SO_4. I do not like to use any organic material, as I believe this is a source of disease organisms which cause root and bulb rots. When these were eliminated from the program, very noticeable improvement was shown. Also, I like to avoid the use of ammoniacals and urea as much as possible. Micro nutrients were added with fertilizers at the rate of: 2 B, 0.09 Mn, 0.02 Cu, 0.09 Zn, 0.75 Fe, 0.03 Mo, 0.01 Co (all stated in ppM); Ca was maintained above 60 ppM and Mg above 5 ppM. Usually with greenhouse crops 3-6 pounds of nitrogen per year per 100 sq. feet is considered adequate. If 500 6 inch pots are equivalent to 100 square feet of bench and 1 quart a week is used for the 3 months period, this would equal one pound of nitrogen per 100 square feet; however, with the leaching used in the program, I feel that actual available nitrogen is much less. Tissue analysis always showed an adequate supply. Phosphorus in the form of

superphosphate is always added to the mix and analysis never shows a deficiency but it was always added to the liquid feed to insure availability. Potash was always sufficient in tissue analysis but in effluent and soil analysis it was always low. The ratio to nitrogen was kept high and in the fall of the year it just seemed to disappear in the pot. For this reason potash was increased in the fall and the increase has not caused any problems but might require a check for salinity.

[In] observation of growing practice in Holland would at first seem that huge quantities of fertilizer are used; however, the nearly 100% organic growing medium combined with a watering procedure which would rapidly leach the fertilizer salts would indicate that the plant is lightly fed. When most people grow plants in pots and feed as heavily as has been observed, I believe that the plants are damaged both by excessive fertilizer and salinity. In my own program I believe that excessive amounts are still being used and in the future plan to reduce the amounts to about two thirds of what is presently being used. In observed programs where solid fertilizer materials are used there is always the feast or famine phenomena: too much when just applied and then none in a short time, resulting in saline damage and then starvation periods. A condition of this kind certainly would not get the best growth response from the plant and in case of the more sensitive species might result in loss of bulbs. Constant liquid feed[ing] avoids this condition.

3. ORGANIC MATERIAL

The potting mixes that have been recommended are usually from 1/3 to 2/3 organic. When the organic material is very course and fibrous the mix has excellent aeration, but as decomposition takes place it becomes a slimy mass that is a disaster area for a root system. Bulbs have shown excellent growth when planted in sphagnum moss for the first few months, then the moss rots out and becomes a wet mess. To save the bulb it must be cleaned and replanted. With the anaerobic conditions in the moss and the disturbance in cleaning and repotting, the bulb suffers tremendously. Composts and manures are some of the poorest materials to use because they rapidly decompose into "jelly-like" anaerobic masses which destroy roots rapidly. Other than environment, the organics are regarded as sources of nutrition for the plant. This is a fallacy because they contain very little nutrition, release it too slowly, and do not give the grower any control. It is much easier to add the [required nutrients] to the water. The answer would seem to be in reducing the quantity of organic material to a low value. In this manner the mix would remain more constant over a long period of time, obviating disturbance of the plant for several years.

Although "Dutch hybrids" can be grown in pure peat and many other mixes, in plastic pots and clay, I believe that using mixes that require the

least care are best. After [I tried] a couple dozen types, the following became standard:

2 parts organic (fibrous)
3 parts sponge-rok #3 (coarse perlite)
2 parts fine sand
1 part charcoal #10 (10 mesh)
2 parts vermiculite #3

Superphosphate and lime should be added in the amount of 2½ pounds of each per yard (equal to about ½ teaspoon per 6 inch pot.) If very acidic organics are used, like sphagnum peat or redwood sawdust, a little more lime will be required to bring the pH into the 6-7 zone. One person told me he used a handful of lime per 6 inch pot. This would undoubtedly be a very bad practice because with such an excess of lime the phosphorus, boron, iron and molybdenum would be "locked out" [not available to the plant.]

Bulbs should not be overpotted. The pot size used should be such that the plant will use the moisture in 2-3 days; otherwise they will not prosper because they stay wet too long. Clay pots, because they disburse the excess moisture by evaporation, suffer the disadvantage of cooling the soil 8° - 10°. If one is careful in watering and uses a very porus mix, the lack of cooling would make a plastic pot much better than clay.

4. LIGHT REQUIREMENTS

One will see pots crowded together in most glasshouses, often with several offsets in the pot. All of these plants are a mass of leaves and none gets enough light. The owner complains of poor bloom. To receive sufficient light, pots should be spaced so all leaves are well exposed to the light and small statured plants should not be shaded by large statured plants. Big plants like *Hippeastrum parodii* require 300 square inches, while *H. anzaldoi* would require only 75 square inches; the "Dutch hybrids" need at least 100 square inches. Offsets should be continually removed or additional space should be allowed so plants get light. The glass in the greenhouse should be scrubbed a couple times a year. Old glass should be sprayed with an etchant to clear it up. Fiberglass houses should be thoroughly cleaned of all glass fiber and dirt and recoated per manufacturer's instructions about every two years.

Only a slight shading can be used in the few weeks of hot weather. The glass should be hosed off every week to remove the dust accumulation. Spring and fall months are critical because they receive only about half the gram-calories [light/heat] as in mid-summer. The same latitude as Chicago receives over 500 gram-calories per day in June, 200 in March, 260 in September, 29 in January. Note that the amount of light in January is only **1/17th** of that in June. Also, remember that the bulk of the species grow between latitudes 10°S and 20°S and many at high altitudes. These areas are noted for their brilliant light. Although no gram-calorie counts are available, other indicators suggest values double those in the United States and winter brilliance is not diminished as in the U.S.

5. VERNALIZATION — REST PERIOD

With the exception of 2 or 3, the species are forced into some kind of vernalization in their native habitat. This is usually referred to as the so-called *rest period*. Several will stay green through the winter and grow well the second season, then, if not forced into dormancy, will go into decline and the bulb is lost. My experiences have been "bitter medicine". I believe ALL amaryllis [*Hippeastrum*] should be vernalized every year. Dutch hybrids handle easily — just withhold water for a month or two then moisten until new leaf growth is well started. If the greenhouse is cool and damp, re-moistening might not be necessary for several weeks.

Although they have a period when they do not grow, *H. blumenavia* and *H. calyptrata* seem to require moisture throughout the year. I have been successful with growing *H. blumenavia* only in fine sand. Three bulbs in a 4 inch pot will bloom every couple of weeks for several months. *H. calyptrata* requires a very porous mix: 4 parts course sponge-rok, 2 parts coarse redwood sawdust, 1 part 10 mesh charcoal, 1 part vermiculite — has grown good plants. There should be enough lime to neutralize the sawdust. This plant is often found growing epiphytically.

Hippeastrum aulica, Amaryllis belladonna, H. blosfeldiae, H. ferreyrae, H. miniata, H. papilio, H. reginae, and *H. striata* need 1 or 2 months of rest. *H. aulica* is often found as an epiphytic plant and in a cool, moist area. *H. papilio*, which is [similar to] *H. aulica*, needs the same treatment. *A. belladonna, H. ferreyrae, H. miniata* and *H. reginae* are from warm, humid areas.

H. caupolicanense, H. divijulianus, H. excobaruriae, H. forgetii (Bolivian form), *H. fragrantissima, H. lapasense, H. leopoldii, H. nelsonii, H. pardina, H. pseudopardina, H. vittata*, and *H. yungacensis* are Bolivian plants found at altitudes from 2000 to 6000 feet where the dry season lasts for a couple months, then there is rain nearly every night during spring. They grow on slopes, lightly shaded by forest in a duff 1-2 inches thick with roots barely covered and extending three feet or more from the bulb. In pots these species seem to need at least two months of rest. Most will lose only a part of their leaves before blooming, then will give a flush of new leaves before the remaining leaves are lost.

Hippeastrum corriensis, H. elegans, H. flammigera, H. moreliana, H. psittacina, H. starkii, H. traubii, H. rubrapicta, H. doraniae, H. mandonii and *H. aglaiae* also need two months or more of rest. This group grows at low altitudes, except *H. mandonii*. All but *H. flammigera, H. starkii* and *H. mandonii* grow in humid, warm conditions. *H. flammigera* grows at 6000-7000 foot altitudes in cool, moist areas. *H. starkii* is from a desert area with a lengthy dry season. *H. mandonii* comes from a hot, humid, rainy area but goes dormant for 2-3 months in the winter. It is possible that it gets too cold for it in California. It seems to prefer small posts and never makes big bulbs. *H. aglaiae* comes up in the spring, blooms, the leaves die back completely, then in 4-6 weeks it grows another flush of leaves which stay on

for about 4 months. It stays dormant for 3 months. It always does this both in the greenhouse and outside.

Hippeastrum anzaldoi, H. cybister, H. evansiae, H. fosteri, H. fusca, H. mollevillquensis, H. petiolata need 3 months or more rest. *H. anzaldoi* from east of Laganilles is found at a slightly higher altitude than *H. evansiae* and in drier conditions. Both should have water withheld completely from late November till after bloom and new leaves are well started. *H. cybister* [comes] from 7000-8000 feet in altitude where there is about 15 inches of rain in early spring, then none the rest of the year. It grows on rocky hillsides amongst cactus. *H. fosteri* comes from hot, deserty areas with probably 15 inches of rain in spring and a long season completely free of rain. *H. fusca* is from 8000 feet altitudes. My experience with this is insufficient to be specific. *H. mollevillquensis*, from a very dry area, grows in steep canyon walls where moisture is retained for a greater length of time than the surrounding hillsides. When it grows leaves, water it. The rest of the time let it be dry. *H. petiolata* is nearly evergreen but needs to be left dry for a long time. A rule of thumb that works well for *H. cybister, H. fosteri, H. fusca* and *H. mollevillquensis* is when leaves get a good start, water. When leaves start to die back quit and give no water until growth resumes. Benlate drenches once a month at 500 ppM seem to benefit them.

Hippeastrum ambigua, H. immaculata, H. tucumana, H. parodii need 4 months rest. *H. parodii, H. immaculata* and *H. tucumana* will have normal appearing leaves for several weeks after watering has stopped, then will die back completely. When watered in early March the leaves pop out and are often 6 inches long within a week. From an early March watering they bloom the last of may and in June. These bulbs occur in very rocky soil *H. parodii* is from altitudes of about 2000 feet in a hot, desert like area with rain only in late spring and early summer; while *H. immaculata* is found at altitudes of 4500-7000 feet. *H. tucumana* occurs at a lower altitude than *H. parodii* in hot, dry conditions. It is much hardier than *H. immaculata* and requires more severe conditions. *H. ambigua* is a hesitant starter and seems to benefit from a hot, dry baking during its rest period. Day periods of 90-95°F seem to complete its vernalization. It should not be watered until 2-3 leaves are an inch high, then increase the moisture when it starts to grow. It doesn't bloom if not thoroughly dried out and given a long rest.

My experience does not allow much comment on several species. *H. angustifolia* seems to like more watering and wetter soil than most, but has a definite cycle and would appear to need a dry winter time. *H. reticulata* needs watering the year round with a late spring time of drier conditions. Bloom is usually in late August or September. *H. ararapina* needs a long rest. *H. iguazuana* goes completely dormant and grows on/near vertical cliffs in deposits of heavy soil but grows in the greenhouse about like most other. *H. kromeri* grows on top of low mountain peaks with bulbs deep in the clay soil. In the greenhouse it appears to want a couple months rest. *H. macbridei* occurs in a harsh, hot area of long drought. I water it when in leaf and stop completely when it shows any sign of growth stoppage. So far it

has taken long rests and doesn't seem to adjust to North American time. *H. viridiflora* grows like *H. macbridei* — when it feels like it — and occurs in a hot, humid, high rainfall area.

In conclusion, the author wishes to qualify all statements in this article with the hope that the conclusions are correct and hopes that it will promote further experimentation and develop better growing methods.

Ed. note: This reprint is included in this issue in response to the many requests we receive each year for cultural information on *Hippeastrum*. It is not intended as the be all or end all statement on growing but serves as a springboard for further exploration into *Hippeastrum* culture. For example, we have heard that Mr. Doran has returned to experimenting with the use of clay, rather than plastic, pots. Also, variations in local climate and availability of supplies may necessitate modifications in materials and techniques.

ERRATA, PART 2

HERBERTIA vol. 46(1):23-32, 1990

Kollmann, F., A. Shmida, and O. Cohen. *Allium tardiflorum* Kollmann & Shmida: A New Autumn-Flowering Species. The following table contains corrections for this article.

Pg.	Line	Erroneous Text/ Mistakes/ Correction Instructions	Correction
23	1-9	No space left between abstract & text; abstract appears to be incorporated into text.	
23	1	autumn-lowering	autumn-flowering
23	14 & 18	Shmida & Dafni (year omitted)	Shmida & Dafni, 1990
23	21	Evenari & Gutterman 1987	Evenari & Gutterman, 1982
24	5	oius	eius
24	6	supre	supra
24	6	dia	diu
24	7	umbella 2-3-4cm	umbella (2-) 3-4cm
24	9	laticra	latiora
24	9	virenti-vinaceae	virenti-vinacea
24	10	post anthesis	post anthesin
24	10	atrovinaceae	atrovinacea
24	22	*Pistacia palestina*	*Pistacia palaestina*
24	31	northern	southern
24	35	Davis 1960	Davis 1950
24	37	Stearn 1898	Stearn 1978
24	38	Karpathos*	Karpathos (Delete asterisk; footnote is incorporated into text.)
24	last	*Allium* pecies	*Allium* species
25	1	(½-)-3/4 of its length	(½-) ⅔-¾ of its length (Figure 1).
25	2	(Figure 1)	Delete (Figure 1).

Pg.	Line	Erroneous Text/ Mistakes/ Correction Instructions	Correction
25	19	*A. paniculatumy*	*A. paniculatum* by
25	26	on populations *A. tardiflorum*	on populations of *A. tardiflorum*
26	legend line 2	Har Árgan	Har Árqan
31	4	2 sentences were deleted. They should be inserted after "following year."	The seeds germinate with the first winter rains. New leafing starts in November and continues till the end of April of the following year.
31	5	Part of a sentence is missing & should be inserted after "April".	and in April nearly all the leaves are already dry.
31	5	of the following year	Delete
31	9	Insert after Codonoprasum	in Israel
		Literature Cited	
31	3	151)158	151-158
31	7,8	**Plant Systematic Evolution**	**Plant Systematics & Evolution**
31	9	**Kew Bulletin 949**	**Kew Bulletin 1949**
31	10	*Notes Royal Bot. Gard.*	**Notes Royal Bot. Gard.**
32	4	**Mem. Society of Botany 4**	**Mem. Soc. Brot. 24**
32	8	**Wildenowia 3**	**Wildenowia 13**
32	12	**Blümenpflanzen**	**Blütenpflanzen**
32	16	Meiklle	Meikle
32	20, 21, 22, 23	Chemistry & Rubber Company	C.R.C.
32	29	Stearn 1978	Stearn 1980
32	last	**Biol. Gallo-Hellen: 51-53**	**Biol. Gallo-Hellen. 6:51-53**